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Technology Review

Edited at the Massachusetts Institute of Technology

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VOLKSWAGEN DOES IT AGAIN

Edited at the Massachusetts Institute of Technology
Volume 82, Number 6
May 1980

Technology Review

FEATURES

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Letters

On the Responsibilities of Newspeople

I was surprised to read (*"Garbage under Glass: What Are Scientists Dishing Out?" by Robert C. Cowen, November, 1979, pp. 10-11*) that my theory about the effect on precipitation of oil pollution on the Gulf of Mexico was a "horror story" and "pure nonsense," and the office that issued the press release was "professionally irresponsible."

The Illinois State Water Survey has for over 20 years carried on practical research on thin chemical films for reducing evaporation from small water supply reservoirs, and during periods of drought we continue to supply limited amounts of chemicals to towns experiencing dwindling surface water resources. At the time of the original press release, the on-scene coordinator of U.S. scientific operations at Corpus Christi said that as much as 10 per cent of the area of the Gulf of Mexico was covered with oil more than one molecule thick spreading from the Ixtoc well. Knowing the water-saving ability of a monomolecular film over a small lake, I believe it was reasonable to speculate on the effect on Midwestern precipitation of a thicker film covering a water surface much greater than the area of the state of Illinois.
Wyndham J. Roberts
Champaign, Ill.

The writer is an engineer with the Water Survey Division of the Illinois Institute of Natural Resources. Mr. Cowen responds:

The earth's atmosphere is a poorly understood mechanism with many complicated interactions and feedbacks. It is all too easy to come up with seemingly plausible theories of cause and effect that later prove simplistic; such errors are especially likely if you are removed, as most hydrologists are, from the large-scale atmospheric processes and their interaction with other atmospheric scales. To put a scientific foundation under the speculation that a substantial oil slick in the Gulf of Mexico would cause mid-continent drought, one would have to show (by extensive historical studies and/or sophisticated computer simulation) that the Gulf is the predominant source of the area's moisture; I think one would find it to be the Atlantic, not the Gulf. You would also have to show that the air-sea system would not adjust to offset any drought potential. And you would have to show that the oil film does in fact behave as Mr. Roberts assumes. There was nothing in the press release to suggest that Mr. Roberts had done that kind of analysis. Mr. Roberts is well within his rights in floating his ideas, but I called the press release summarizing it a "horror" story because I felt it unnecessarily alarming, issued with inadequate checking although presumably in good faith.

Synfuels and Conservation

Charles A. Stokes (*"Synthetic Fuels at the Crossroads," August/September 1979, pp. 24-33*) fails to recognize alternatives to capital-intensive coal and shale synfuels. Smaller, more-efficient cars; urban, farm, and forest waste (full utilization could provide as much as 10 quads of energy a year, nearly half our oil imports); good insulation, passive solar design, and solar hot water in all new structures; and cogeneration of heat can provide those millions of little savings that can add up. The small amount of high-temperature energy for such jobs as melting steel can be found in our domestic fossil fuels and garbage until well past 2000 if we stop wasting our energy.

In short, Mr. Stokes would divert our attention away from less-polluting, more-permanent, and cheaper alternatives toward short-term, Band-Aid solutions. If we concentrate on synfuels as Mr. Stokes suggests, we (or our grandchildren) will find ourselves at some time in the future back on square one, desperately looking again at solar and renewable sources.
Andrew Heugel
Stony Brook, N.Y.

Mr. Stokes responds:
The sad fact is that we need both Mr. Heugel's approaches and mine. We have a gap in our supply of usable energy at affordable prices for at least the next 30 years. By "affordable" I mean a broad definition: we can afford to pay more for synfuels than imported oil if all the money we pay stays in the U.S. The synfuels I talk about replace fuels derived from crude oil to keep our present system going, "buying" time for developing the alternatives Mr. Heugel suggests and others such as vastly improved power cycles. Above all, we need to be open-minded and consider all approaches.

Water Flow and Storage in the West

Ronald Probstein (*"Water for a Synthetic Fuels Industry," August/September, pp. 36-43*) oversimplifies a number of issues pertinent to his subject. Most serious is his attempt to draw conclusions about en-

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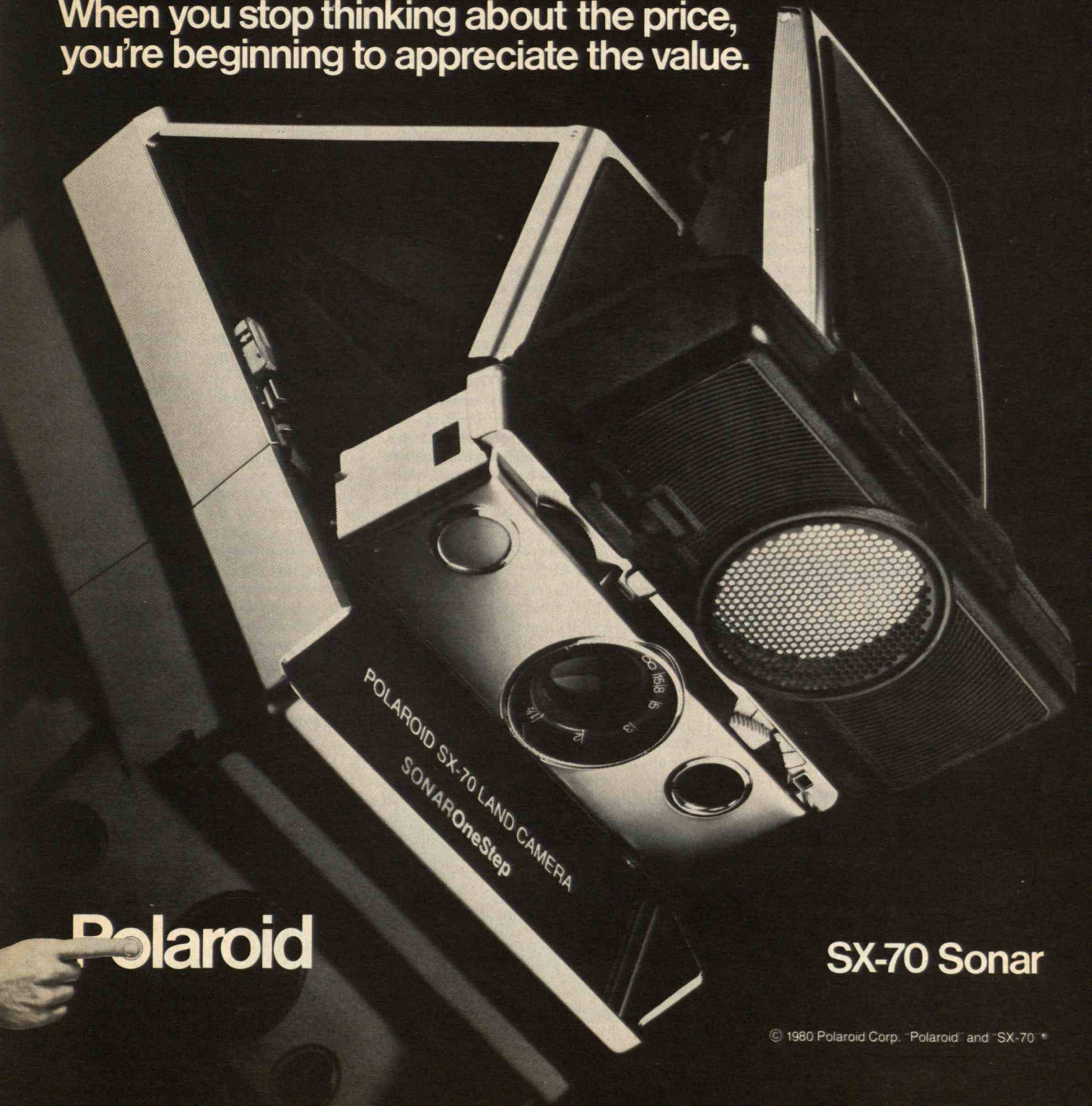
And if by now all of this is beginning to sound like a wonderful bargain, it's obvious you're the kind of person who can discern the difference between the value of something, and its price.

When you stop thinking about the price, you're beginning to appreciate the value.



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SX-70 Sonar

vironmental acceptability by comparing mean annual river flows with the water consumption requirements for synfuel plants. While synfuel plants use water at a nearly steady rate, river flows vary tremendously from season to season and year to year. If water is consumed from a river at a rate that is 5 per cent of the mean annual rate of flow, that same consumption rate corresponds typically to about 50 per cent of the lowest weekly flow rate that is expected on the average every ten years. The comparison with mean annual flow would suggest, as Probstein intended, relatively innocuous effects. However, comparison with low-flow conditions gives a very different picture and one which should be quite distressing to those concerned with the biological health of our rivers, as well as with recreational and other needs for freshwater. This subject is discussed in considerable detail in our article referred to by Probstein (*Science, vol. 199, pp. 623-624, 1978*).

On another issue, Probstein criticizes us for considering in that article an upper limit for water use by synfuel plants which is considerably higher than the value he believes is attainable. We carefully stated there that our purpose was to consider a range of estimates of potential water use for synfuels, a range provided not by us but by industry, government, and academia, and then to discuss the corresponding range of environmental consequences. We were not trying to predict the future, but rather to develop a framework allowing us to explore the consequences of possible futures. Given the great economic and technological uncertainties of synfuel processes, this scenario approach still appears most sensible to us.

John Harte
Mohamed El-Gasseir
Berkeley, Calif.

The writers are associated with the Lawrence Berkeley Laboratory of the University of California. Professor Probstein responds:

Harte and El-Gasseir correctly note that mean annual flows do not characterize low flows. It is for this reason that all published synfuel plant designs incorporate appropriate reservoir capacity in cases where plant locations make this possible. Harte and El-Gasseir are justified also in suggesting a scenario approach with respect to synfuel plant water use based on data obtained from "industry, government, and academia" — but only when these data do not violate fundamental precepts of sound engineering design.

Liability: Tilting at a Windmill

If Charles Babcock or any other attorney (*see "Product Liability: Excellence by Edict or Effort," October 1979, p. 77*) were to file nonmeritorious lawsuits against major automobile manufacturers on a contingency-fee basis "because there is every incentive to sue and no disincentive not to," he would soon find himself in the hands of a lawyer specializing in bankruptcy. Contingency-fee attorneys advance the costs of litigation out of their own pockets and are only repaid and compensated for their time if the client's case is meritorious and the attorney is able to obtain a recovery for the client. For an attorney to file and pursue a nonmeritorious case is truly to tilt at the product liability windmill. Recently we successfully represented a brain-damaged premedical student in litigation over alleged defects in an automotive product. The case had to be tried twice over a period of seven months, and the costs advanced in behalf of the client approached $500,000. Clearly, Mr. Babcock is wrong in asserting that "a plantiff's lawyer stands to lose nothing but time in the event the suit is lost. . . ."

I also take issue with Mr. Babcock's allegorical comparison of a court with a "circus" in which "housewives and barbers" and "other nontechnical people" make the findings and set the damages, and his claim that some of the expert testimony on which those monies are based is "beneath contempt." As an engineer and an attorney, I believe in the jury system and in the ability of everyday people as peers to judge the credibility of witnesses and assess the weight to which their opinions are entitled.

William S. Hart
Los Angeles, Calif.

The author is a partner in Harney and Moore, attorneys at law, Los Angeles. —Ed.

Integrating Energy

May I take Charles A. Stokes and Ronald F. Probstein (*August/September 1979, pp. 24-43*) one step further by suggesting:

☐ Build a fission reactor adjacent to an oil shale deposit to (1) generate electric power, (2) supply heat required to expel the oil from the shale, and (3) desalinate or purify water used for these processes, and others.

☐ At a relatively nearby site, mine coal and ship it to the site of the fission plant.

☐ At the fission site, grind the coal and dissolve it in a hydrocarbon fraction derived from the oil shale. Use the processed water to send the hydrocarbon-coal mixture to Mid-Western and Eastern states for use to generate electricity.

Monroe Burk
Columbia, Md.

The author is professor of economics at the University of Baltimore. Though he has not analyzed the particular examples chosen, Dr. Stokes agrees that the writer "makes an excellent point: integrate energy operations whenever possible to achieve a sharing of capital for on-site and off-site facilities, to concentrate facilities in remote areas that can be approved, and to increase overall thermal efficiency." —Ed.

Adding Electricity to the Sun

J. G. Asbury and his colleagues ("*Electric Heat: The Right Price at the Right Time," December/January, pp. 32-40*) left out one cost-effective possibility for off-peak electricity use: the electric night-time heating of passive solar residences. Such residences can readily store adequate energy in their structural fabric to last through the daytime hours, so heating is needed only at night.

C. James Bier
Ferrum, Va.

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A newly-expanded program of travel now offers an even wider choice of journeys to distant and fascinating areas of the world, including for 1980 the islands of the Galapagos, the Nazca Lines and the desert of Peru, the Amazon, the unusual lands of southern India, an expanded program of discovery to the ancient cities of Greece, Asia Minor and the Aegean, new and more extensive itineraries in ancient Egypt and in the Far East and in India and the Himalayas, as well as the ruins of Tiahuanaco in Bolivia and the Stone Age world of New Guinea, the lands of New Zealand and Australia, the islands of the Seychelles, and game-viewing in the wilds of Kenya and Tanzania.

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SOUTH AMERICA and THE GALAPAGOS: A choice of itineraries of from 12 to 29 days, including a cruise among the islands of the Galapagos, the jungle of the Amazon, the Nazca Lines and the desert of southern Peru, the ancient civilizations of the Andes from Machu Picchu to Tiahuanaco near Lake Titicaca, the great colonial cities of the conquistadores, the futuristic city of Brasilia, Iguassu Falls, the snow-capped peaks of the Andes and other sights of unusual interest.

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THE SOUTH PACIFIC and NEW GUINEA: A primitive and beautiful land unfolds in the 22-day EXPEDITION TO NEW GUINEA, a rare glimpse into a vanishing world of Stone Age tribes and customs. Includes the famous Highlands of New Guinea, with Sing Sings and tribal cultures and customs, and an exploration of the remote tribal villages of the Sepik and Karawari Rivers and the vast Sepik Plain, as well as the North Coast at Madang and Wewak and the beautiful volcanic island of New Britain with the Baining Fire Dancers. To the south, the island continent of Australia and the islands of New Zealand are covered by the SOUTH PACIFIC, 28 days, unfolding a world of Maori villages, boiling geysers, fiords and snow-capped mountains, ski plane flights over glacier snows, jet boat rides, sheep ranches, penguins, the Australian "outback," historic convict settlements from the days of Charles Dickens, and the Great Barrier Reef. Optional visits can also be made to other islands of the southern Pacific, such as Fiji and Tahiti.

CENTRAL ASIA and THE HIMALAYAS: An expanded program of three itineraries, from 24 to 29 days, explores north and central India and the romantic world of the Moghul Empire, the interesting and surprising world of south India, the remote mountain kingdom of Nepal, and the untamed Northwest Frontier at Peshawar and the Punjab in Pakistan. Includes the Khyber Pass, towering Moghul forts, intricately sculptured temples, lavish palaces, historic gardens, the teeming banks of the Ganges, holy cities and picturesque villages, and the splendor of the Taj Mahal, as well as tropical lagoons and canals, ancient Portuguese churches, the snow-capped peaks of the Himalayas along the roof of the world, and hotels which once were palaces of maharajas.

THE FAR EAST: Itineraries which offer a penetrating insight into the lands and islands of the East. THE ORIENT, 30 days, surveys the treasures of ancient and modern Japan, with Kyoto, Nara, Ise-Shima, Kamakura, Nikko, the Fuji-Hakone National Park, and Tokyo. Also included are the important cities of Southeast Asia, from Singapore and Hong Kong to the temples of Bangkok and the island of Bali. A different and unusual perspective is offered in BEYOND THE JAVA SEA, 34 days, a journey through the tropics of the Far East from Manila and the island fortress of Corregidor to headhunter villages in the jungle of Borneo, the ancient civilizations of Ceylon, Batak tribal villages in Sumatra, the tropical island of Penang, and ancient temples in Java and Bali.

Prices range from $2,350 to $3,900 from U.S. points of departure. Air travel is on regularly scheduled flights of major airlines, utilizing reduced fares which save up to $600.00 and more over normal fares. Fully descriptive brochures are available, giving itineraries in detail and listing departure dates, hotels, individual tour rates and other information. For full details contact:

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Economics in Disarray

Kenneth E. Boulding is director of the Institute of Behavioral Science and emeritus professor of economics at the University of Colorado at Boulder. He is a regular contributor to Technology Review.

Lucy Dillon

To celebrate the beginning of the 1980s, a number of economists were invited by Professor David Mermelstein to issue brief statements on the current economic situation, especially regarding inflation, to be published in the *New York Times*. Wassily Leontief, Martin Feldstein, Milton Friedman, John Kenneth Galbraith, Abba Lerner, and I were among those who responded. The various replies reflected, of course, the well-known economic prejudices of the different authors, but there was an overall lack of consensus. Similar dissension existed in the 1930s and 1940s, when the Keynesian revolution was slowly taking over the profession. However, nobody seems to be taking over anything now, and no revolution seems to be in process. We seem instead to be facing widening diversities and disagreements.

The Charismatic Persuaders

This disarray is both strange and discouraging in light of the fact that over the last 50 years the information system available to economists has improved enormously. Although we now have far more accurate information about all segments and aggregates of the economy than we had in 1929, we are a profession increasingly torn apart — we seem largely to have stopped talking to one another. Most of the economists mentioned above know one another personally, and have reasonably friendly personal relations — at least they are willing to shake hands when they meet at gatherings and conferences. But there are no circles of correspondence anymore — nothing like the wonderful series of letters that went on between Ricardo and Malthus, no real attempt to discuss the differences, no real meeting of minds. We are all on separate trains going out on the spokes of a wheel to our respective suburbs, and the center of town is vacant.

Most sessions at meetings of the various economic associations are technical. Controversial subjects tend to be avoided and there is no opportunity for real dialogue. I have always argued that economists are remarkably nice people, for only nice people could have applauded something like the Paretian optimum, which suggests that there is no such thing as envy or greed, or indeed hardly any of the seven deadly sins, and that if A gets better off while B gets no worse off, B is supposed to be delighted. Perhaps, however, we have become too damned nice to solve our tragedy of the intellectual commons. We each stake out our little claims, and everybody shouts from his own housetop, reasonably out of earshot of all the others.

Unfortunately, this is not a trivial problem for the welfare of the human race. Perceptions of legitimacy, rather than human experiences of well-being, really rule the dynamics of the social system. Many notions and institutions regarded as quite legitimate have in fact been proven injurious to human welfare. Indeed, it is one of the greatest tasks of collective human wisdom to bring legitimacy and welfare closer together, and it is at least part of the business of economists to foster this process. When observers see a group of economists exhibiting wide disagreement and obviously failing to communicate, this undermines the legitimacy not only of economics but of the whole intellectual enterprise. The way is then open for the plausible and charismatic persuader who is likely to make things worse rather than better.

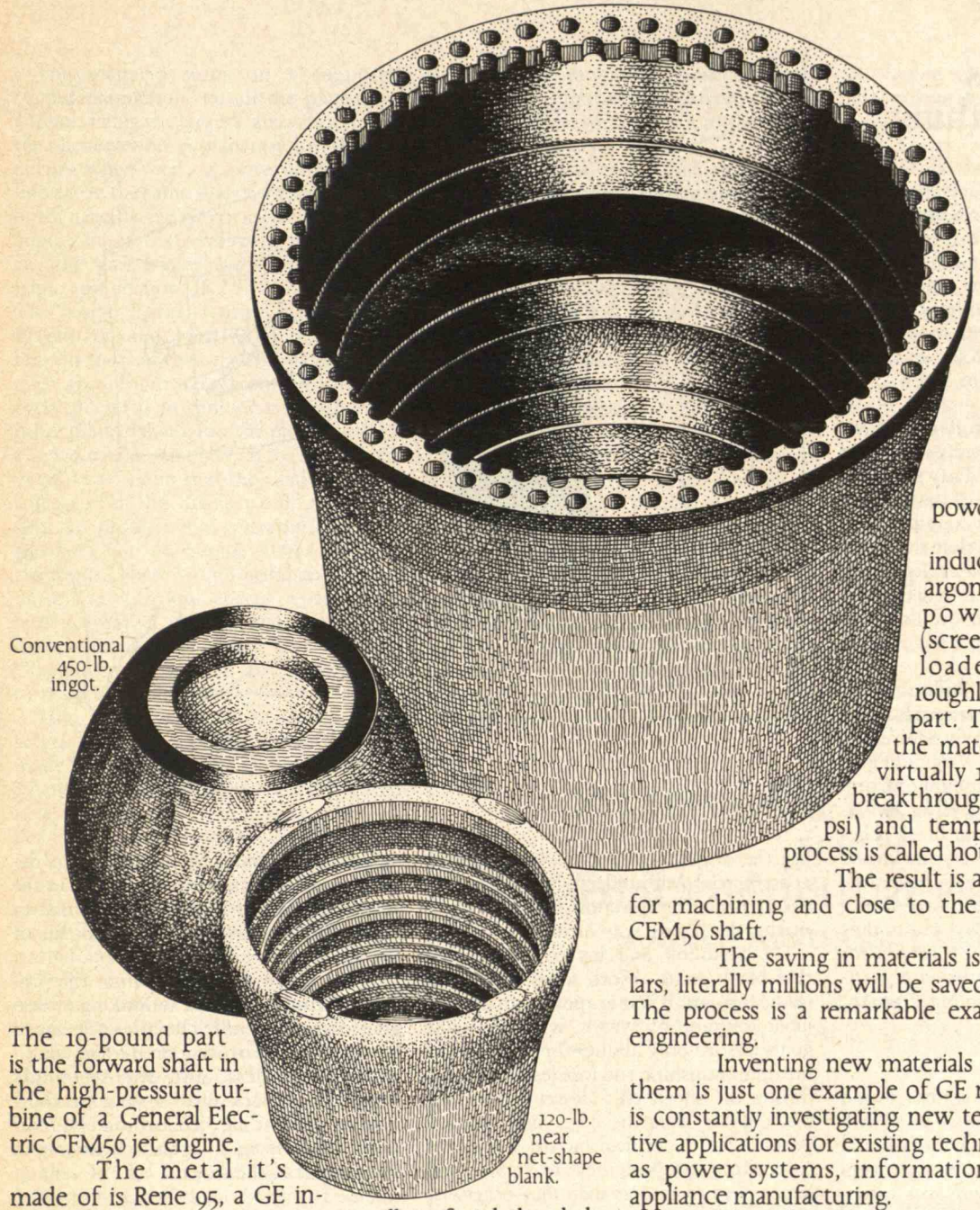
Groping for the Elephant

Perhaps — and this is the most cheerful thought I have had all day — we are simply facing the famous problem of the blind men and the elephant, in which we each see a different aspect of what is essentially a unified problem. The first blind man is represented by those who see the main source of inflation as supply restrictions or lack of productivity increases. In good old neoclassical economics, the solution is simply to readjust the relative price structure, with some prices going relatively higher and some lower. Why should this cause inflation? The answer can only be that there are institutional restrictions on the lowering of money prices and wages. However, if we can never reduce a money price or wage, the only way to adjust the relative structure is to increase some and not others, or to increase some at a faster rate, which brings inflation.

Then there are those — the second blind man — who see inflation coming primarily from increases in the stock of money or liquid assets, which, in turn, come partly from government deficits and in part from the creation of liquid assets by the banking and financial system. Without adequate data about the structure of assets, it is hard to say how much inflation derives from what effects. One great defect of the economic information system is that too much effort is devoted to income and too little to assets. If we could correct this, we

Continued on page 20

Why should it take 450 pounds of metal to make a 19-pound part?



The 19-pound part is the forward shaft in the high-pressure turbine of a General Electric CFM56 jet engine.

The metal it's made of is Rene 95, a GE invention. Rene 95 is an exotic superalloy of nickel, cobalt, columbium, tungsten and 17 other elements. To fabricate a forward shaft from Rene 95 by conventional methods, you start with a 450-pound ingot. After forging, pressing and machining, you end up with a single 19-pound shaft...and more than 400 pounds of expensive scrap.

That's a distressing waste of critical raw materials and of the energy it takes to mine and refine them.

So GE engineers turned to near net-shape forming: fabricating the finished part from a blank shaped as closely as possible to the shape of the finished part.

But how could such a blank be created without starting with a 450-pound ingot? To solve that problem, GE engineers developed a truly unique application of powdered metallurgy.

Virgin or vacuum induction-melted Rene 95 is argon-atomized to create a powder. The powder (screened for particle size) is loaded into containers roughly shaped like the final part. Then, in an autoclave, the material is consolidated to virtually 100% density (that's a breakthrough) at high pressure (15K psi) and temperature (2000° F.). The process is called hot isostatic pressing.

The result is a 120-pound ingot ready for machining and close to the shape of the finished CFM56 shaft.

The saving in materials is more than 70%. In dollars, literally millions will be saved over the next decade. The process is a remarkable example of cost-effective engineering.

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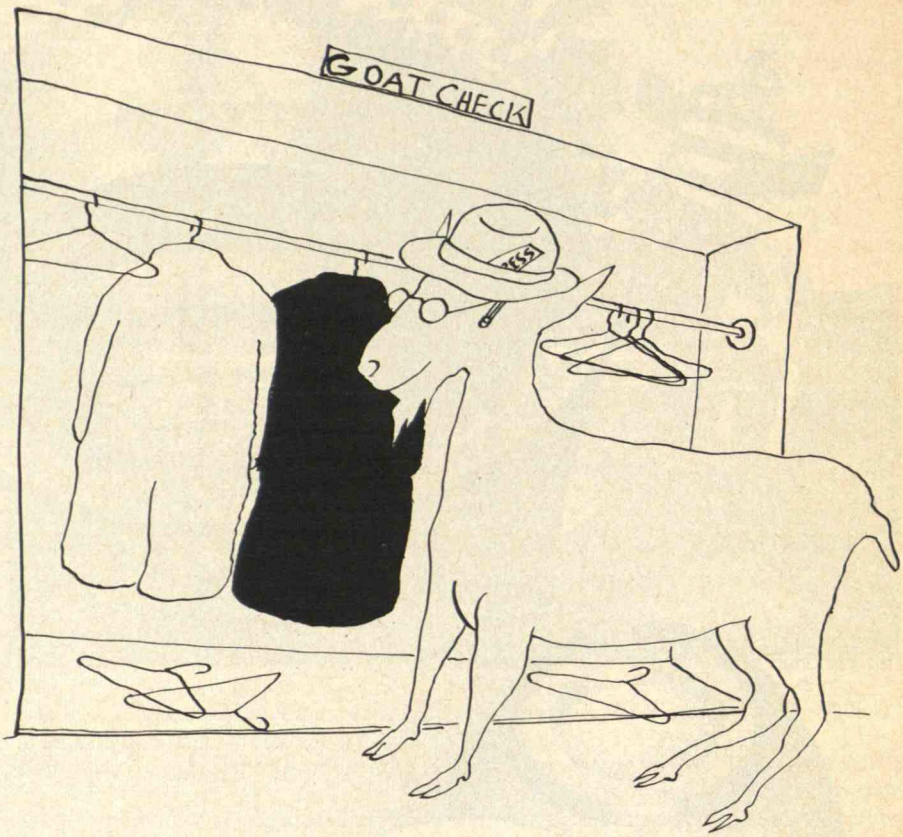
Science Stories in Goats' Clothing

Robert C. Cowen, science editor of the Christian Science Monitor, *is former president of the National Association of Science Writers and is a regular contributor to the* Review. *He holds S.B. and S.M. degrees in meteorology from M.I.T.*



Michael Crawford

Along with the heavier stuff that flows across editorial desks are frothy items that lighten the news budget. Tney're called "brighteners" in the jargon of the trade. A lot of them are about science and technology. The trouble is that they usually are one-shot tidbits that leave the story only partially told, if indeed they don't completely misinform. So it's sometimes good fun to follow up a few and see what they lead to.

Take the black-robed Bedouin, for example. Last January, Amiram Shkolnik and Arieh Borut of Tel Aviv University and C. Richard Taylor and Virginia Finch of Harvard University's Museum of Comparative Zoology asked in a letter to *Nature*: "Why do Bedouins wear black robes in hot deserts?" After all, everyone knows that black cloth absorbs more heat than white cloth. But the Bedouins aren't stupid, or as the four scientists put it, they "would have optimized their solutions for desert survival." Yet there they are wearing black robes and herding black goats.

Black Is Best

Upon investigation, the scientists found out that indeed the black robes do absorb two and a half times as much radiation in the visible part of the sunshine spectrum as white robes do. But there was essentially no difference in the net heat gain of people wearing black robes compared with those wearing white. The scientists speculated that as the robes flow in the wind, a bellows action or chimney effect might be carrying the heat away. So, since there was no heat penalty in wearing black, it was sensible for Bedouins to make robes from the black hair of their goats. After a press release from *Nature*, news media spread the story.

However, Dr. Shkolnik and his colleagues Razi Dmi'el and Avi Prevulotzky have subsequently pointed out that the findings as stated are too simplistic. They beg the original question: why are desert goats black? And, indeed, by focusing on desert heat, the question gets the whole matter the wrong way around.

Dr. Shkolnik and his colleagues find that black goats absorb some 80 percent of the insolation and evaporate an appreciable amount of water, whereas white goats absorb only about 40 percent of the incoming sunshine and lose less water. But during the short, cold desert winter, the black goats have the edge, and this appears to be the critical factor. They need to produce less body heat to survive and hence need to eat less than they otherwise would.

The scientists explain that the lack of water during the long, dry summer does not seem to be crucial for the survival of these goats. The animals have specialized physiological mechanisms that allow them to go without drinking for long periods. But their loose, shaggy coats are poor insulators. Apparently, selection pressure has centered on energy (body heat and food intake) economy rather than water economy.

Can the same be said for the Bedouin themselves? Referring to the robe study, Drs. Dmi'el, Prevulotsky, and Shkolnik say it now "would be interesting to determine whether, during the winter in the desert, the black robe has a role similar to that which we assign to the black fur of the goat."

From these findings comes the important conclusion that in looking at desert ecology, the entire climatic cycle has to be considered. Focusing on the "obvious" — heat, dryness, and the seemingly paradoxical black coat — can be thoroughly misleading. Unfortunately, *Nature* didn't issue a press release about that aspect of the story.

The "Jupiter Effect"

Another "brightener" that keeps coming back to haunt science writers and astronomers is the so-called "Jupiter effect" — a planetary lineup that supposedly threatens to trigger earthquakes in 1982. Although debunked in the scientific literature, the facts have never caught up with the publicity. The Astronomical Society of the Pacific (ASP), located in quake-conscious California, says the notion of planet-caused earthquakes is the subject of many queries it receives. This concern continues to surface in my mail, too.

The scenario turns on a supposed "superconjunction" of all the planets — Jupiter, being the largest, gives its name to the phenomenon. A planetary conjunction occurs when two or more other bodies line up on the same side of a given celestial body, usually the sun or Earth. Mars and Jupiter have been waltzing through the sky this past winter and spring in a rare triple conjunction. In 1974, in their book *The Jupiter Effect*, astrophysicists Steven Plagemann and John Gribbin called attention to what they claimed would be an even more "unusual alignment, in which every planet is in conjunction with every other planet: that is, all the planets will be aligned on the same side of the sun." They went on to claim that the tidal forces resulting from this lineup would tug at the sun to produce an overabundance of sunspots and encourage increased solar eruptions. These would bombard our atmosphere with high-energy particles, affecting weather and causing shifts in air mass that would affect Earth's spin. Changes in the spin, in turn, would tend to trigger earthquakes.

This shaky train of reasoning drew scoffs from the scientific community but made headlines that are still remembered. Therefore, last summer the ASP asked Belgian astronomer Jan Meeus, who earlier had shown the weakness of the thesis in a technical journal, to take another look at the "Jupiter effect." His conclusion that "the complete chain [of reasoning] must be considered as having a probability of zero" deserves wider publication.

Meeus shows that there will be no "superconjunction." The closed grouping of the planets, as seen from the sun, will still be scattered over a 93-degree sector. Moreover, there is no scientifically established connection among planetary alignments, sunspots, weather, and earthquakes. But Dr. Meeus makes a perceptive prediction. If, by chance, there are major quakes in 1982, especially in California, someone will claim the "Jupiter effect" has been proven. It will be interesting to see where the story goes from here.

Double Star or Double Vision?

Then there's the question of the second "sun." About two and a half years ago, E.R. Harrison of the University of Massachusetts suggested that the sun may be keeping company with another star — a dark companion whose gravity influences the solar system. He attributed anomalies in the rates of certain pulsars (objects that emit radiation in regularly spaced pulses) to a Doppler effect resulting from the acceleration of the solar system in the direction of the pulsars.

Few scientists took this theory seriously. Nevertheless, subsequent papers on the subject haven't ruled out the possibility of a solar companion. The most likely candidate for the effect now seems to be a massive black hole.

H.F. Henrichs and R.F.A. Staller of the University of Amsterdam have shown that it is unlikely that any body massive enough to produce the presumed effect could remain undetected. However, this still doesn't rule out the possibility that the effect is produced by a passing neutron star or black hole. And Serge Pineault of the University of British Columbia showed that such an encounter is theoretically possible. J. Kirk at the Max Planck Institute for Physics and Astrophysics has shown from a study of expected effects on comet orbits that any such passing object must be moving faster than 20 kilometers a second. Daniel Wilkins of the University of Vienna can find no evidence for a fast-moving neutron star in his studies of comet orbits. But he thinks an encounter with a massive black hole, 350 times as massive as the sun and moving at 100 kilometers a second at a distance of some 15,000 times the Earth's orbital radius, remains plausible. Thus, although the intriguing suggestion that the sun is part of a double star system no longer seems viable, we just might be flirting with one of the most exotic objects in the galaxy.

The moral of all this is to beware of those off-beat items that appear at the end of the evening newscast or are attractively boxed with a cartoon in your newspaper. My own favorite was an item widely published in the early 1950s that announced the invention of a radioisotope-powered "atomic battery" with enough power to supply a large office building. I'm still waiting for the follow-up on that one. □

Margaret Grammer

Brazilian Alcohol: In the Tank, Not on the Table

To sidestep increasing oil prices, Brazil has embarked on a national program of producing alcohol for motor fuel. The nation's abundant sugar cane crop sweetens the prospects for success.

Geographical accident has catapulted Brazil into a key role in the search for energy alternatives. The pressure of overwhelming dependence on oil imports has led Brazil to turn urgently to alcohol as a fuel alternative.

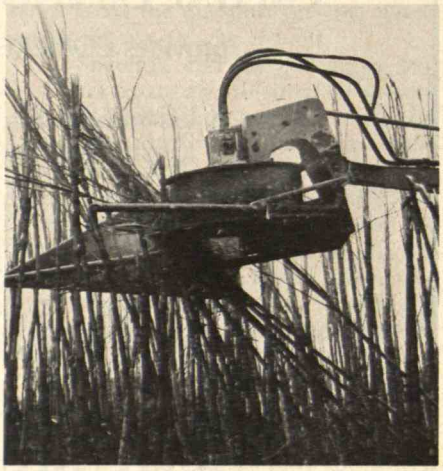
Brazil's first venture into alcohol as fuel was in the 1920s, when car owners in the sugar-rich northeast turned to alcohol mixtures and even pure alcohol as fuel because gasoline was too expensive to import in that region. Later, when oil prices went down, alcohol fuel was phased out. But in 1973, when OPEC pushed oil prices up, a light went on in the collective memories of Brazilian policymakers, and research into the alcohol alternative went into full gear.

The National Alcohol Program (Proálcool) was founded two years later to promote and finance the development of new biomass resources (chiefly sugar cane) and to expand existing distilleries. The goal was to establish a new fuel to be marketed nationwide — 80 per cent gasoline and 20 per cent alcohol — and to promote a market for 100 per cent alcohol fuel to be used in adapted engines.

Adapting Cars to Alcohol Power

Ordinary cars can run on a mixture of up to 20 per cent alcohol with no adaptations. However, to run effectively on pure alcohol, internal combustion engines must be adapted because the burning properties of alcohol are different from those of gasoline. Alcohol produced to burn with gasoline must be anhydrous (free from water). However, cars designed to run 100 per cent on alcohol can use hydrated alcohol, which is cheaper than the gasoline/alcohol mixture.

Most auto manufacturers in Brazil have accepted the challenge of switching to alcohol-powered cars. The first engine designed, rather than merely adapted, to run on alcohol was for the Fiat 147, which was approved for sale to government officials in March 1979.



Energy from sugar — food to fuel. A young cane worker takes a bite of sugar cane (above). Ethyl alcohol for powering automobiles can be produced from the fermentation of any plant containing sugar, including not only sugar cane but also sorghum, sugar beets, cassava, corn, eucalyptus, and potatoes. The sugar cane harvester (left) cuts the cane, the first step in alcohol production. At the processing plant (right) the cane is converted to alcohol. Engineers at the Institute of Technological Research say that private ownership of distilleries could significantly reduce the cost of alcohol to the consumer. A home plant drawing on 60 acres of sugar cane could produce enough fuel to run a small truck and stationary motors for household electrical needs. (Photos: Copersucar)

Now the government has signed an agreement with the National Association of Automotive Vehicle Manufacturers: the commercial production of 250,000 alcohol-fueled vehicles will commence in July, 1980, with a government commitment to provide the necessary fuel.

Brazilians expect alcohol cars to be priced 10 per cent higher than conventional vehicles, but government officials have suggested that longer financing terms and lower taxes on alcohol cars would provide incentives to choose them. Also, with Brazil's retail gas prices the third highest in the world after Denmark and Sweden, alcohol is even more appealing.

General Motors in Brazil has been testing an engine that will run with only modest adjustments on almost any liquid fuel. A version that will run on gasoline, alcohol, or a mixture of the two will be on the market in 1981.

As Brazil makes the transfer to alcohol, the nation is planning carefully to be sure that the automobile and alcohol industries don't out-produce each other, thus creating surpluses of one or the other. So far, only government officials have been permitted to own cars designed or adapted to operate on alcohol; other Brazilians have used gasohol — the 20-per-cent-alcohol, 80-per-cent-gasoline mixture. But soon private owners will be permitted to drive converted cars without being licensed by the government.

Owners of gasoline-powered cars can convert their engines to handle the 100-octane alcohol fuel by:

☐ Scaling down the combustion chamber to raise the compression ratio and cope with the higher-octane ethyl alcohol,

☐ Enriching the air/fuel ratio in the carburetor from 14:1 for gasoline to 9:1 for alcohol, and

☐ Changing the ignition timing.

The cost of these modifications is about $250. Ford of Brazil was the first manufacturer to announce the sale of kits with which authorized mechanics can convert Ford cars, and the government plans to publish conversion specifications for other cars.

Do-It-Yourself Distilleries

The Institute of Technological Research (IPT) has published a manual containing the technical and economic information necessary to build "minidistilleries" for home production of ethyl alcohol from sugar cane. Engineers at IPT say private ownership of distilleries could significantly reduce the cost of alcohol to the

Biomass Fuel for the United States?

Can gasohol, for which Midwestern motorists are now scrambling so avidly, really ease automotive fuel problems in the U.S.? Most analysts seem to have little optimism for the short run; and the long run is obscured by a cloud of unanswered questions.

On one issue there is general agreement: gasohol, when it consists of gasoline diluted with no more than about 10 per cent ethyl alcohol derived from biomass, can be burned in any gasoline-powered automobile with no increase in pollutants and insignificant risk to the engine. The addition of ethyl alcohol boosts the octane rating of the fuel by several points and — according to tests reported to the American Chemical Society last fall by Pincas Jawetz, an independent energy consultant — the miles per gallon in normal service by at least 5 per cent. Enthused Mr. Jawetz, "Gasohol in all probability allows us to save at least two units of petroleum for each unit replaced."

But in making that optimistic statement, Mr. Jawetz ran afoul of one of several controversial, sticky issues.

Though all the major American oil companies permit the sale of gasohol at company-branded gas stations, they exercise considerable caution in managing it — and especially in their handling of noncompany "brand X" gasohol. The overall picture looks like this, according to *Oil & Gas Journal*:

☐ Shell Oil Co. will accept credit card sales for all gasohol sold at branded gas stations, but the company has given notice that none of that gasohol is produced by Shell. A company disclaimer puts sole responsibility for the quality of the product on the retailers.

☐ Gulf Oil Corp. and Exxon U.S.A. honor credit cards for all gasohol sales.

☐ Texaco, Inc., which has moved aggressively into the field, currently distributes its own gasohol through 600 branded stations in eight states — and this is scheduled to grow to 1,100 by spring. But at Texaco it's cash only and no-thank-you to credit cards for *unbranded* gasohol.

The gasohol now being sold in the U.S. is the product of distillation processes that use more energy than the resulting ethanol product contains. Indeed, according to Frederick F. Hartline in *Science (October 5)*, the distillation steps alone require more energy than the fuel value of the alcohol, and to that must be added the cost of growing and harvesting the original biomass and fertilizing the land for the next crop. It looks like an expensive way to reduce oil imports.

New technology may eventually change these unfortunate energy balances. Arthur D. Little analysts think that energy consumption can be reduced by 50 per cent with a new extraction process, but its development is only beginning. Other systems with less spectacular savings are also in sight, but their use is unlikely until 1990.

Most ethyl alcohol made in the U.S. today comes from grain; corn is the most widely used feedstock. According to the American Institute of Chemical Engineers, corn at $2.50 to $2.80 per bushel results in ethyl alcohol (with today's subsidies) at $1.60 to $1.70 a gallon. Gasohol enjoys a waiver of the 40-cents-per-gallon federal gasoline tax and of many state gasoline taxes; so gasohol and gasoline are nearly competitive in price at the pump. This subsidy actually represents a social cost, say T. G. Alston and J. G. Asbury of Argonne National Laboratory: grain alcohol is going into gasohol instead of substituting for petroleum-derived ethanol in industrial chemicals.

ADL economists take a dim view of the future of gasohol. The price of grain-derived ethanol will go up apace with oil; and if the U.S. converted fully from gasoline to gasohol, making the ethanol would require 40 per cent of the total U.S. grain production.

Today's prodigious production of ethyl alcohol in Brazil utilizes sugar cane and cassava from 1.25 million acres of agricultural land. Brazil has a "privileged situation in this enterprise," Luiz S. Pimental of the Instituto de Pesquisas Technologicas of São Paulo told the ACS last fall: it has large amounts of low-cost agricultural labor, a favorable climate, and large areas of available land. The United States has no similarly generous proportions.

In the longer-term race for liquid fuel from biomass, Brazil may have even more impressive advantages. Professor Melvin Calvin of the University of California at Berkeley now has a plantation of Brazilian *Euphorbia lathyrus* in California whose latexlike sap is yielding the equivalent of 10 barrels of petroleum per acre per year at $40 per barrel. He thinks genetic improvements may yield a 10-fold increase in per-acre production.

Professor James L. Kuester of Arizona State University shares Professor Calvin's enthusiasm for biomass. The amount of plant material renewed in the world each year corresponds in energy to roughly 50 times the current consumption of petroleum, he told the ACS. "There is little doubt that biomass will eventually emerge as the primary feedstock. The only question is the timing . . ." — *J.M., L.A.P* ☐

consumer. A home plant drawing on 60 acres of sugar cane could produce enough fuel to run a small truck and stationary motors for household electrical needs, and the solid waste could be converted to fertilizer. Not many Brazilians have 60 acres to devote to this project, but for large landowners in isolated regions, the do-it-yourself distillery could mean a new way of life.

Ethyl alcohol, or ethanol, can be produced from the fermentation of any plant containing sugar — which includes not only sugar cane but also sorghum, sugar beets, cassava, corn, eucalyptus, and potatoes. Brazil had settled on high-yield cane for its alcohol but recently decided to diversify into wood and cassava. Dependence on a single crop, engineers say, could be risky were the crop to fail.

Fuel consumption increases 10 to 15 per cent with alcohol, thus balancing the gain from alcohol's higher octane. This naturally high octane makes the use of lead additives unnecessary, and alcohol combustion does not produce carbon monoxide. Alcohol does, however, produce acetaldehyde, an organic substance that results from incomplete oxidation of the alcohol when burned. Acetaldehyde, in high concentrations, can cause skin and eye irritations as well as serious damage to the lungs. It also smells bad and harms vegetation. In the United States, acetaldehyde levels in the atmosphere may not exceed 360 milligrams per cubic meter by law.

Research engineers say that if alcohol engines are well designed, ethyl alcohol pollution will, at worst, be similar to that of gasoline. Catalytic filters could eliminate acetaldehyde emissions altogether. The danger is further minimized, they say, by the substance's short life: it quickly combines with other substances and is rendered inert.

Of greater concern is polluting waste created by alcohol production. Each liter of alcohol produced also creates 12 liters of toxic waste material which, if allowed to flow into waterways, kills fish, algae, and plants. The waste can possibly be used as fertilizer or solvent or even reconverted into methyl alcohol: methanol. Or it may be used for fuel in the distilling process.

Pollution concerns aside, users of alcohol-converted engines have noted significant corrosion in the parts of the engine that are exposed to alcohol. Alcohol is less viscous than gasoline and so tends to corrode tubing and carburetor parts. The 400 alcohol-powered cars of Telesp, São Paulo's telephone company, have shown consistent deterioration in carburetors, pumps, and fuel tanks. Solutions to the corrosion problem run from chemical additives to tin-plated fuel tanks.

Telesp, São Paulo's telephone company, now operates about 400 alcohol-powered cars such as the one shown below. Most auto manufacturers in Brazil have accepted the challenge of switching to engines designed or adapted to run on alcohol.

Alcohol-powered cars also start poorly in cold weather, as alcohol has a higher vaporization temperature than gasoline. Experiments are being conducted to find an effective method to preheat the alcohol ignition. Another problem is difficulty running alcohol-powered engines at slow speeds — a problem in city driving.

The alcohol engine will require some years to perfect, even after it is in general use. According to General Motors of Brazil, the automotive industry will master alcohol technology by 1982. In the meantime, corrosion problems will continue. Also, until alcohol stations or gas stations with alcohol tanks are widespread, alcohol-driven cars will be restricted to a 75-mile radius of major cities.

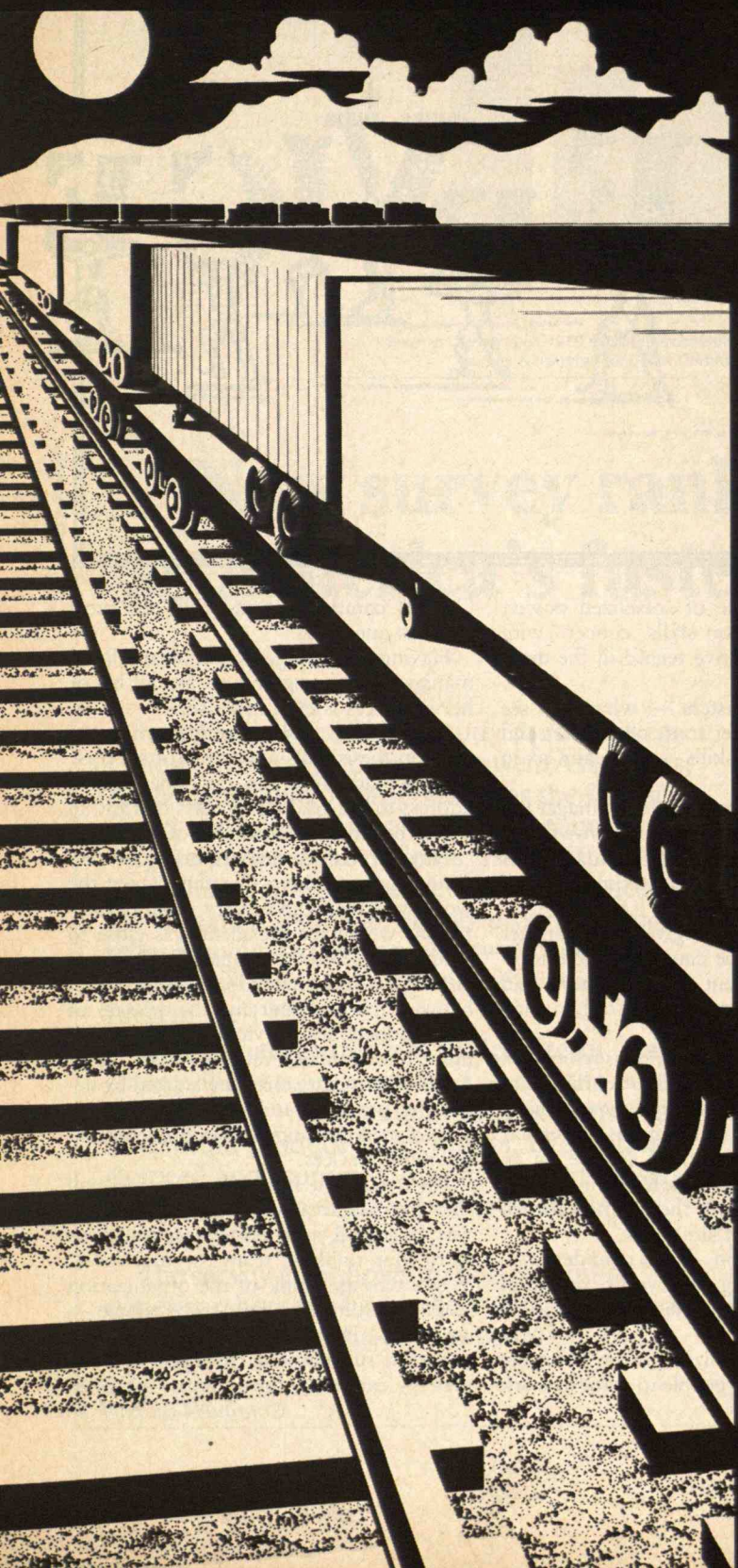
Alcohol has been used in applications other than automotive fuel, as well. The recently nationalized Light, the São Paulo state-owned electrical power company, is transferring one of its power plants to alcohol for an experimental period.

Brazil's alcohol program has all the signs of becoming an international first. But ironically, it suffers from the petroleum shortage. Government restrictions on the sale of diesel fuel recently left many of the nation's trucks paralyzed on roadsides, awaiting the next month's allotment of diesel fuel. Consequently, many of the alcohol distilleries in Rio de Janeiro and São Paulo were threatened with shutdown. Among the trucks by the roadside were those that carry sugar cane from the fields.

Margaret Grammer is a free-lance journalist living in São Paulo, Brazil and a former staff writer for the Latin America Daily Post. □

Myth:

Truck trailers on the public highways move freight most efficiently.



Fact:

Freight railroads save highways, tax dollars and energy by piggybacking truck trailers.

Mile for mile and pound for pound, today's freight railroads are up to four times more fuel-efficient than big trucks. Shippers recognize this advantage. That's why piggybacking truck trailers and containers is the fastest-growing segment of the rail freight business.

But there's another consideration. While every wage-earner and manufacturer in America subsidizes our public highway system, trucks are destroying that vital system at an alarming rate.

Congress' watchdog, the General Accounting Office, said in a blistering July 1979 report: "Excessive truck weight is a major cause of highway damage. The rate of highway deterioration will slow down if excessively heavy trucks are kept off the highways... A five-axle tractor-trailer loaded to the current 80,000 pound federal weight limit... has the same impact on an interstate highway as at least 9,600 automobiles."

It is ironic that the American public is subsidizing the destruction of its own highways. It is also unnecessary, because a logical alternative already exists. This is the vast, fuel-efficient steel network that links every part of America: our modern freight railroads.

Railroads handle more than a third of the nation's inter-city freight and have the capacity to handle even more. Today, escalating highway repair costs and dwindling oil supplies make America's freight railroads more vital than ever.

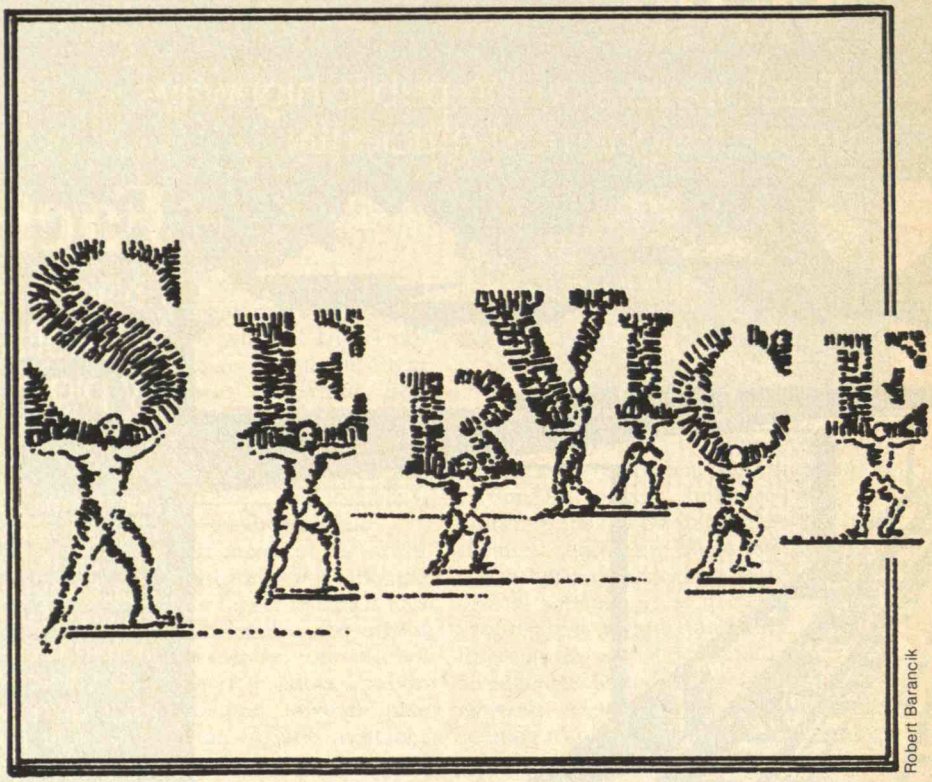
For more information, write: Alternative Dept. T Association of American Railroads, American Railroads Building, Washington, D.C. 20036.

Surprise:

America's freight railroads carried more than 3,000,000 piggyback truckloads last year —and never left a pothole.

Successful Leadership: A Spirit of Service

Warren Bennis has been watching people and their organizations ever since studying for his doctorate in psychology (1955) at M.I.T.'s Sloan School of Management. After 20 years in academic administration at the State University of New York at Buffalo and the University of Cincinnati (president, 1971-77), he will assume the position of distinguished professor of business administration research at the University of Southern California next fall.



Robert Barancik

James L. Hayes is an educator turned manager; formerly dean of Duquesne University's School of Management, he is now president and chief executive officer of the American Management Association, the largest vendor of management education in the world. During a recent visit, I asked him about the training and qualifications he would urge for managers of today's businesses. I liked his answers, and I want to share some of our conversation with you.

Bennis: The better management schools are often ranked in academic terms — which faculty publishes more, whose methods are more scientific, and so on. But are these the qualifications that really make a difference in the success of managers?

Hayes: We have found in studying a great number of managers that their competencies tend to cluster into four principal groups:

☐ Socio-emotional competencies — self-control, spontaneity, perceptual objectivity, accurate self-assessment, stamina, and adaptability. One could have guessed some of these, but we have been able to confirm them among successful managers.

☐ Entrepreneurial abilities — efficiency and "proactivity" (i.e., initiative), both of which are very important.

☐ Intellectual abilities — logical thought, the ability to conceptualize, the diagnostic use of concepts, and memory.

☐ Interpersonal abilities, which have become so popular in teaching in the last few years; we identify them as self-presentation, interest in the development of others, concern with impact, use of unilateral power, use of socialized power, oral communication skills, concern with relationships, positive regard in the management groups.

The driving clusters — what you see manifested in either traits or motives and in self-image and skills — are really six in number:

☐ Efficiency orientation: the manager has the need for achievement, he knows things can be done better; he loves to set goals and objectives just as a natural way of operating.

☐ Proactivity, which gives the manager the feeling that she can influence the future; managers want to be initiators, and they're problem preventers rather than simply problem solvers.

☐ Diagnostic use of concepts, which is a real mastery of deductive learning, of formulating hypotheses and then drawing out hypothetical solutions as a regular way of life. This is social science on an applied basis; the real skill is bringing the basic concepts and the framework of management to all situations.

☐ Self-preservation — self-confidence — a sense of knowing what you're doing, of decisiveness without hesitation, of consistency.

☐ The use of socialized power, behaving in ways that cause people to want to work together.

☐ Oral communication skills, the most obvious one of all.

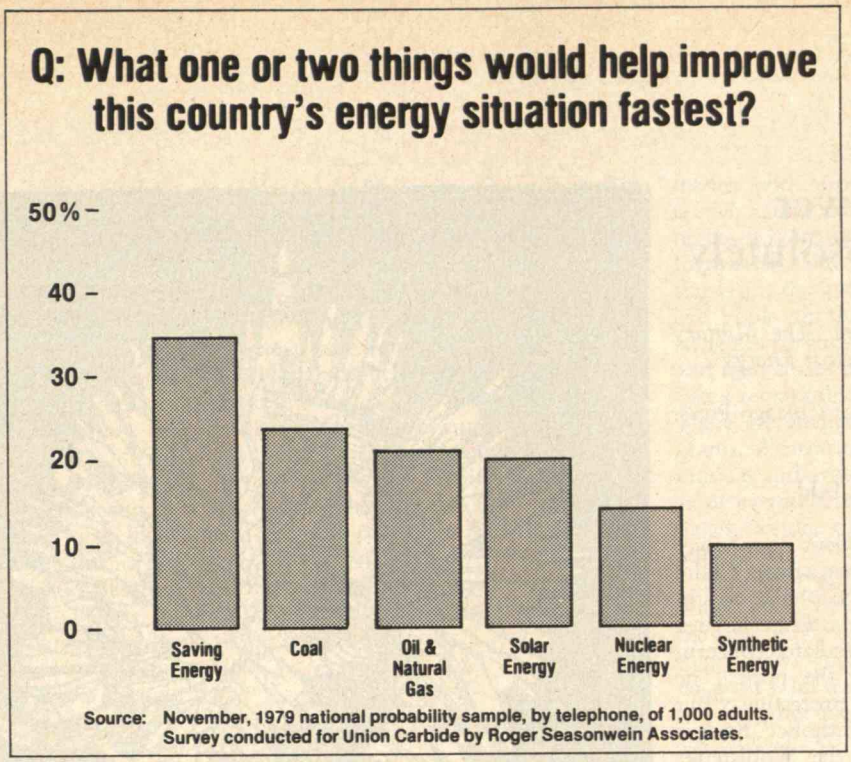
Having knowledge is important for a manager, but being able to use all his or her resources is even more so.

Bennis: How does a would-be manager develop these tools and traits of success? What would you say in a commencement address to the graduating class of 1980 in one of our major institutions of learning?

Hayes: My commencement address would go something like this: Once the world was made up of very small organizations where the president was close to the products and the people. The business grew. This necessitated interjecting a level between the president and the delivery of the products and services. It grew some more, and another level was added. Never forget that the organization started by delivering products and services to people and formed itself upward in order to render more services.

Now that you are graduating, you will step into organizations that are already very large and your temptation will be to start your thinking from the top down. That's wrong. Think of the organization as the instrument to best serve people — customers. The consumer movement does not come substantially from product failures — except in the minority of cases

Continued on page 20



New survey ranks conservation as America's fastest energy option.

In a new public attitude study conducted for Union Carbide by Roger Seasonwein Associates, Americans ranked conservation as the fastest (chart above) and one of the most economical ways to improve the nation's energy situation. This finding takes on particular significance as the Congress shapes an energy program which relies heavily on developing new technologies to deliver substantial amounts of synthetic fuels in the 1990's.

Appropriate as this is in the long-term, many energy analysts are convinced — and the public now agrees — that a commitment to conservation would produce faster results. In addition to speed and economy, Americans rate conservation highly on its environmental advantage — second only to solar.

The survey also shows that 56 percent of American homeowners believe their homes are not as energy efficient as they could be, and a majority of these homeowners feel that they can't afford to make them more efficient. The public expresses strong support for government programs to help homeowners improve this situation, and also favors programs to help industry become more energy efficient.

In short, our survey reveals a large constituency for energy policies which exploit conservation's potential for fast results. The survey is available on request.

How to get a copy:

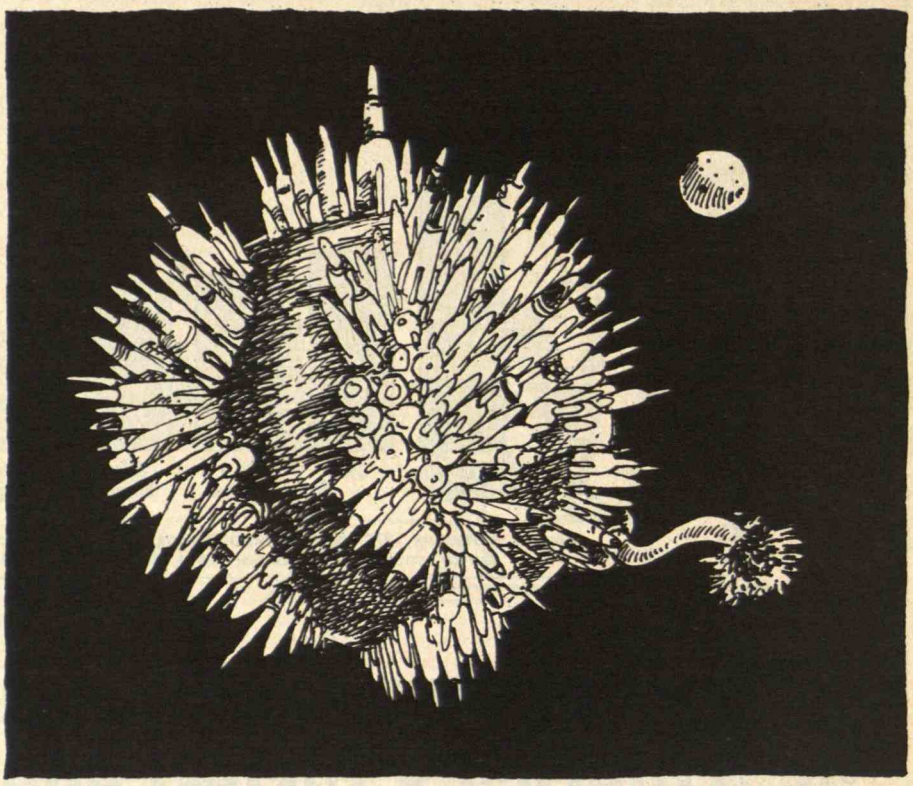
For a copy of this study, write "Conservation Study" Union Carbide Corporation Box TR39R, 270 Park Avenue, New York, New York 10017.

UNION CARBIDE

Absolute Power Destroys Absolutely

Swords from Plowshares: The Military Potential of Civilian Nuclear Energy
Albert Wohlstetter, *et al.*
Chicago, Ill: University of Chicago Press, 1979, $5.95 (paper)

Reviewed by Bernard T. Feld



Jon McIntosh

In the early 1950s, President Eisenhower appointed the well-known actress Claire Booth Luce, a converted Catholic, as ambassador to Rome. Soon after her arrival in the holy city, a story circulated concerning her first visit with the pope. The punchline had the pope protesting, "But . . . but I already *am* a Catholic!" So it is with the discovery, by the Wohlstetter circle, that the so-called peaceful atom is identical with that used in nuclear bombs. If nuclear weapons proliferation is to be curbed, they conclude, there must be a drastic curtailment of the spread of nuclear fission power outside the industrialized Western world.

The argument for curbing Third-World nuclear programs becomes even stronger when one realizes (as Vince Taylor and other ecologist-economists have been pointing out for years) that nuclear power will neither be needed nor economically competitive for decades to come *(see Nuclear Power for the Third World? page 46)*. Any binding decision about a nuclear future, most particularly regarding the need for reprocessing and breeding, can be safely, if not profitably, postponed until the next century. (The Germans have an expression for it: *Das kommt nach dazu* — the reasoning was convincing before, but the new argument helps.)

Swords from Plowshares is built around an essay by Albert Wohlstetter, "Moving toward Life in a Nuclear Armed Crowd?" first published in *Minerva* and based on a 1975 study commissioned by the U.S. Arms Control and Disarmament Agency (ACDA). The essay spells out the effects of nuclear weapons proliferation in detail, region by region throughout the world, and concludes that a world of proliferating nuclear weapons will be far more dangerous than the one in which we are living — not only for the so-called nuclear weapons states but also for other nations. Various aspects of the proliferation problem — including the aforementioned lack of need for nuclear power, the technology of nuclear weapons production and its relation to peaceful nuclear energy technologies, and the technical and psychological bases of nuclear deterrence — are discussed in detail by Wohlstetter's six collaborators.

A Shaky Finger in the Dike

In an enthusiastic forward, Fred C. Iklé, head of the ACDA during the Nixon and Ford administrations, gives Wohlstetter credit for programs instituted during the Ford administration and continued under President Carter that insist on extremely stringent antiproliferation safeguards as a condition for any substantial foreign aid program involving nuclear energy. He points out that Wohlstetter's essay predated by a few years the Ford-Mitre report, which is generally credited with initiating the U.S. nuclear nonproliferation policy.

Iklé is right. But credit for this policy is hardly likely to ensure Wohlstetter a firm place of honor in history. Our nonproliferation policy has been only marginally successful at best — a shaky finger in a dike that is rapidly developing more holes than we have fingers. Both Iklé and Wohlstetter admit, albeit reluctantly, that the policy of stemming nuclear weapons proliferation by restricting nuclear power proliferation is doomed to fail because of noncooperation on both sides. Our industrialized allies are unable to resist lucrative trade with the Third World in nuclear power reactor systems, and these deals are often "sweetened" with hard-to-get reprocessing or enrichment technology. At the same time many developing nations have been eager to obtain the latest nuclear technology not because of economic need but because it provides them with the satisfying "option" of taking the prestigious step of developing a nuclear weapons capability.

Wohlstetter's response is straightforward. He says we should, in this case, emulate the Soviets and provide our allies and the Third World (or at least countries we can convince to accept it) with a nuclear umbrella so unequivocally powerful it is preferable to the expensive and extremely dangerous course of going it alone. This approach represents, in my view, a dangerous misreading of the real world.

A Powerful Bee Sting

The acceptance by Soviet satellites of the Soviet nuclear umbrella is not a question of intellectual conviction; it is purely a matter of Soviet "dictat" — they have no

choice. However, nations outside the Soviet sphere are entirely justified in harboring doubts about whether the United States would be willing to risk nuclear annihilation to protect their independence.

Furthermore, even if Wohlstetter is able to demonstrate, with some mathematical precision, that it would take hundreds of nuclear missiles to give the Japanese the ability to deter a Soviet nuclear attack (i.e., destroy, in retaliation, a substantial fraction of the Soviet population and industrial capacity), it is much more likely that the Japanese will adopt the French "sting-of-the-bee" approach to deterrence if they decide to "go nuclear." That is, the Japanese will bank on the conviction that no sane Soviet leader would start a nuclear war against them if he knew it would lead to the destruction of several important Soviet industrial centers. Such a "sting-of-the-bee" approach requires only the ability to deliver a few dozen reasonably powerful and accurate nuclear missiles to Soviet targets.

Given the overwhelming pressures toward nuclear proliferation, then, what are the alternatives to Wohlstetter's great power hegemony of America's and Russia's arming to the teeth with ever more lethal and numerous nuclear weapons?

The alternatives — and optimism about the survival of the human species demands that there are some — must lie in methods for restraining the threat and use of nuclear weapons and for guaranteeing the gradual reduction in their numbers. In the absence of substantial disarmament of the nuclear superpowers, or at least a reasonable guarantee that such disarmament is on the near-term agenda, it will be impossible to curb the desires of many more nations — some 30 or 40, according to Wohlstetter — to join the nuclear weapons club.

One of the first steps to reduce the glamour of nuclear weapons should be an agreement between the nuclear powers on the unacceptability of the first use of nuclear weapons. The Chinese and Indians have already publicly proclaimed a "no-first-use" doctrine, so there are only four nuclear powers to go!

In addition to such a public acknowledgement of the non-use of nuclear weapons in *any* international conflict, we must revive the SALT process — though not necessarily in its previous bilateral, détente-dependent form — to reduce the current ridiculous Soviet-American overkill capabilities.

For some 30 years, the United States and the Soviet Union have been locked in an unproductive and potentially lethal competition for the accumulation of destructive nuclear capacity. By a kind of miracle, this virus has not yet spread out of control to the rest of the world. The foremost issue of the rest of this century, clearly stated but not resolved in this important book, is whether and how the nuclear weapons virus can be permanently contained. One point, however, is certain. Any solution must involve the most intense, determined efforts, both intellectual and political, of the entire world.

Bernard Feld is a professor of physics at M.I.T. and editor-in-chief of the Bulletin of the Atomic Scientists. □

An Enthusiasm Marathon

Gödel, Escher, Bach: An Eternal Golden Braid
Douglas R. Hofstadter
New York: Basic Books, 1979, 777 pp.; $18.50

Reviewed by Daniel Kleitman

Mathematical arguments can have a form of beauty all their own. The "elegance" or simplicity and power of some arguments have universal appeal and can inspire enthusiasm even in an audience with little or no mathematical training.

Most people identify mathematics with those aspects that gave them the most trouble in their education — from memorizing multiplication tables, sorting out confusing and improbable word problems, to struggling with fractions. But even such people can appreciate a beautiful argument. Unfortunately, they may never have seen one.

Douglas Hofstadter, a young professor of computer science, writes of mathematics — more particularly mathematical logic and games, perceptions, genetics, computation, and physics — with enormous feeling. He loves the arguments in these fields, and he describes his book, *Gödel, Escher, Bach*, as a statement of his religion.

This is a strange volume. Its 700-odd pages contain an enormous quantity of information about all sorts of subjects — scientific and aesthetic — with primary thrust in mathematical logic and the biological bases of reasoning. It shares this feature with various academic texts. But *Gödel, Escher, Bach* is nothing at all like a text — it is an outburst of enthusiasm. Unfortunately, after a few pages of enthusiasm, the average reader of the average book on this subject grows bored, struggles perhaps for a page or two more, and then closes it forever. Hofstadter has taken remarkable pains to avoid this fate. There are changes of pace: pictures, diagrams, illustrations, headings, dialogues, musical and artistic analogues, and diversions everywhere. At no point in the 700 pages can one open to a display of ordinary prose.

Though I did not fall asleep on this book, I had difficulty reading it for two reasons. First, *Gödel, Escher, Bach* is in many ways inappropriate for all audiences. It is far too gimmicky and patronizing for someone who is conversant with the subject matter. It is too massive and diverse for a student; he or she might profit from parts of it but probably would not plow completely through it.

My second problem with *Gödel, Escher, Bach* is my tortoiselike dislike of Hofstadter's gimmicks and jargon. They do perk up flagging interest, but they embarrass as well.

Browsing in the bookstore, the tortoise notices his friend Achilles looking over his shoulder.
Tortoise: Should I read this book?
Achilles: It has wonderful arguments and insights scattered throughout.
Tortoise: Insights about what?
Achilles: Anything and everything under the sun.
Tortoise: I don't have time to read about everything.
Achilles: But how else will you learn everything about everything?
Tortoise: How did Hofstadter learn everything about everything?
Achilles: He studied for years in school and thought hard about the interrelationships among his interests.
Tortoise: Will reading this help me to think about interrelationships?
Achilles: No, but it might make you want to.
Tortoise: But if I didn't want to, would I ever glance at this book?
Achilles: Look, it is full of enthusiasm, and that is contagious. You'll love it.
Tortoise: But I hate dialogues. The book has oodles of silly dialogues.
Achilles: You can buy the book and skip the dialogues.
Tortoise: I can fail to buy it and skip the dialogues.
Achilles: I will buy it for you as a gift.

Tortoise: Must you?

Hofstadter proves that one can, with enough ingenuity and enthusiasm, convey the spirit and substance of mathematics in a way that can engage the intelligent outsider. But I am disappointed that he did not use his expository talents to convey some short, beautiful, and complete mathematical arguments. His readers could then feel unmitigated pleasure from the subject and learn to share his love for it, and an audience for such stuff would no doubt come into being. Instead, 99.9 per cent of his readers will not come close to finishing his book. Any joy they feel will be tempered by guilt. This may even bring about a backlash of resentment against mathematical arguments.

Hillel was able to state the essence of Judaism while standing on one foot. Similarly, *Gödel, Escher, Bach* is written to appeal to a reader who is standing on one foot. The message, however, does not appear and we are ultimately disappointed. If Hofstadter is to popularize his religion, he must find a way to summarize his message.

Daniel Kleitman is head of the Department of Mathematics at M.I.T. □

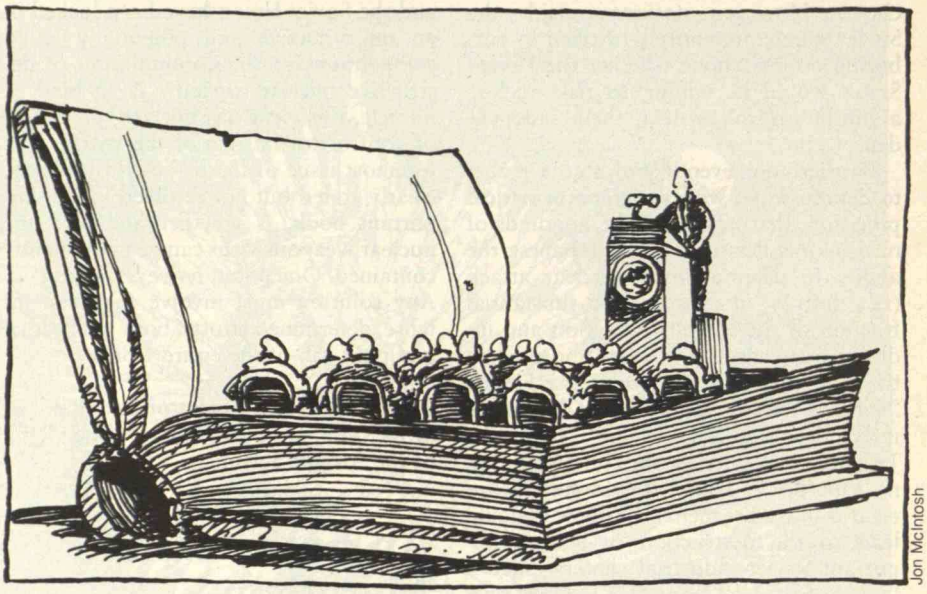
From Conference to Book in 15 Easy Months

Government, Technology, and the Future of the Automobile
Douglas H. Ginsburg and William J. Abernathy, eds.
New York: McGraw-Hill, 1980, 483 pp., $29.95

Reviewed by Eric O. Stork

In October 1978, Harvard's Ginsburg and Abernathy cochaired an important symposium on "Technology, Government, and the Automotive Future" for industry, government, and academic experts. Now they have published a volume with almost the same title.

However, in spite of the prestige of the authors, their institution, and the publisher, the volume is *not* a book. It looks like a book, all right. It feels like a book, and at $29.95 it surely costs more than even a good book should cost. But what you get for your 30 bucks is little more than a 483-page hardcover reprint of some 27 papers presented at Ginsburg and Abernathy's symposium.



Jon McIntosh

The dustcover touts the work as including a description of the present regulatory scheme, proposals for feasible alternatives, and an exploration of the economic effects of regulation. That will impress many librarians enough for them to issue a purchase order. Such a book would indeed be a valuable research tool. But this volume is a far cry from its dust-jacket description. Were it not for the protection of the First Amendment, prosecution under section 5 of the Federal Trade Commission act for deceptive advertising would seem to be appropriate.

Small type identifies Ginsburg and Abernathy as "editors" of the volume; "collators" is a more accurate word. The papers are bunched into seven chapters, each of which begins with brief notes on what the individual papers cover — no analysis, no critique, just sort of a narrative table of contents. There is a key-word index. There is a list of participants at the symposium. Finally, there is a brief bibliography that appears to be someone's afterthought.

Conference vs. Book

Compendia of conference papers can be useful, but they should not be represented as a *book*, for there is a great deal of difference between writing a book and holding a conference. Writing a book is a lonely, tedious task. A book claiming to do what this one does should set forth in a coherent format the relevant issues, facts, and assumptions, provide cogent analysis, and offer well-reasoned conclusions.

A conference, on the other hand, is a gregarious event. The purpose of presenting papers at a conference is to stimulate discussion; interaction among the participants is the real objective. Were it otherwise, everyone could save a lot of time and money by getting the papers in the mail.

A good conference attracts relevant movers-and-shakers who, through their interactions in corridors, at meals, and in hotel rooms, learn much more from one another than they do from the formal presentations. It is an important achievement to get people who rarely communicate under other-than-formal circumstances to interact informally.

Yet our social rituals rarely seem to encourage this interaction. To justify the time involved, participants must be made to believe that they will make an important contribution by presenting a paper. And since no one would dream of telling a mover-and-shaker exactly what he or she should talk about, conference papers tend to be advocacy pieces on whatever subject the writer happens to be interested in. Rarely do the papers have a common focus — certainly these do not. The real product of a conference — the increased understanding by the participants of one another's points of view — cannot be put between hard covers except perhaps by an historian or social anthropologist.

It is common to give each conference participant a copy of the papers presented. I and all other participants in this conference carried them home in lovely, padded, red loose-leaf binders emblazoned with Harvard's crest. The notebook is still on

my shelf, in case I ever want to refer to it.

It's not that the papers are not worth reading. Indeed, most are. Since it would be invidious to those not mentioned to discuss one or two of them here, I won't do so. My point is that simply binding between hard covers a collation of papers that have little relationship to one another does not give them coherence or common thrust. And since the papers will not be individually indexed in library card catalogs, researchers who could use the ideas they present will probably never find them.

I hope that Ginsburg and Abernathy will soon produce what this volume's advertising promises. Their long involvement in the field would make their work eminently worthy of close study. But they have not done it this time. A collection of conference papers does not a book make, no matter how prominent the editors.

Eric O. Stork, as deputy assistant administrator of the EPA, directed the U.S. auto emission control program from 1970 through 1978. He is currently a visiting professor at Purdue University's Institute for Interdisciplinary Engineering Studies.

A Rebuttal

Eric Stork sent a copy of this review to the book's editors, and we've given William Abernathy the opportunity to respond.

The purpose of the book is well illustrated by Eric O. Stork in his topical review of publishing-industry practices. The automotive dilemma facing the nation today is much like the familiar problem of the blind men who independently feel and then describe the elephant. One, standing near a foot, fears a public safety menace, another, near the mouth, sees an uncontrolled guzzler, while the rider may perceive that both he and the elephant are under seige. But, since all are influencing the elephant's direction, it is just as important to understand these men as it is to understand the elephant itself.

The real goal of our book is to present all these players in action within their chosen roles. With the exceptions that labor and consumer views are not well represented, this goal has been realized. At the same time, it is not surprising that a skilled central player in this industry such as Eric Stork should call for a consistent and rational ordering of the automobile dilemma in any book he would endorse. However, it would be unlikely that anyone who had not viewed the elephant so long from its polluting end could write a book that he would accept. The point that may be missed is that the book's purpose is not to introduce rationality where little exists. The regulator's demand for simple consistent rationality where none exists does not miss the point of the book — it is the point! And thank you, Eric Stork, for making it.

Eric Stork replies:
Fine. But if that is the "real goal" of the book, why say something entirely different on the dustcover? □

Boulding/Continued from page 6

might be able to resolve some theoretical dilemmas. Nevertheless, the evidence seems very strong that the inflation of the 1970s is closely related to the decline — almost the disappearance — of the taboo on federal budget deficits and the corresponding monetization of these by the financial system.

The third blind man is the one who sees inflation as the result of positive feedback from the rise of one money price or wage. A rise in a money wage increases the money price of the product, which reduces the real wages of others and produces pressure to increase their money wages. This raises the price of products, which, in turn, feeds into the original wage. The solutions suggested here are either price and wage controls, à la Galbraith (which have occasionally worked for very short periods), or something like Lerner's ingenious market anti-inflation plan, which requires firms that raise the dollar value of their net sales above some norm to buy credits in the capital market from firms whose net sales have risen less than the norm. The "classical" solution to a process of generally rising money prices and wages — which feeds upon itself — is to limit the money stock. This, however, would perhaps result in unsold commodities and unacceptable levels of unemployment. The easy way out is to continually raise the money stock to justify each new level of prices and wages — and this gives continuous inflation.

The fourth blind man sees only expectations. When prices are rising, people think they will go on rising; so people continue to increase their offers to buy and prices keep on rising. In the economy as a whole, this is reflected in an increasing velocity of money circulation. This velocity obviously has a limit, but as that limit is approached, depression begins to set in and again government authorities expand the money stock.

Looking for a Few Good Blind Men

The fifth blind man is myself — a voice crying in the wilderness. I suddenly have remembered something that economists have forgotten: when an employer hires somebody, she sacrifices the interest she might have received on the money spent on the wage for the hope of profits on the product of the work. We would ordinarily expect that profits would be higher than interest rates to compensate for the uncertainties involved, although if people really got a big charge out of employing other people, this might not be necessary. What has happened in the 1970s, I argue, is that interest rates are now adjusted to the expectation of inflation, that interest has been eroding profit, and that we are now forced into more and more inflation to keep the real rate of profit above the real rate of interest.

There may be a few more blind men that I haven't identified, but we still don't have an elephant. Perhaps some benevolent foundation should bring us together and force us, or at least pay us, to engage in dialogue, though how we pay anybody to listen to others is a problem that no foundation so far seems to have solved. The first and last such occasion I remember occurred 30 years ago when American University in Washington collected about ten economists in a room for two days to talk about the Impact of the Union. The volume that emerged is not much to read, so maybe it is no good locking economists together until they reach agreement. It could be that we are waiting for a mind, someone who can find the whole elephant and persuade everybody else that it exists. Come on, you bright young economists, break out of your itty bitty models and come and find the elephant. Great will be your reward. □

Bennis/Continued from page 14

where life and limb are threatened, and of course we must do something about that. But when we fail to deliver the products to people at the point where the economic exchange takes place — the point at which each party believes more is being gained than lost — we are in trouble. If someone buys a product for $100, the merchant wants that $100 rather than the product, and the buyer wants that product more than the $100. That relationship takes place at the top of the satisfaction curve. But if the merchant delays a week to deliver, the satisfaction curve is on the way down; and when the product is finally delivered, the customer doesn't want it any more but would rather get the $100 back. In the meantime, he or she would like to spend the $100 on a new trade-off. The customer criticizes the product because he or she is no longer getting it at the highest point of satisfaction.

In addition, we must remember the people who work for us; we must be sensitive and negotiate with our employees so they sense their relationship to other individuals in the complex organization.

Your generation has the opportunity to change the spirit of service into one closely oriented to customers and employees. The degree to which we are able to satisfy those who purchase our goods and services, and those who work throughout the organization, determines how successful we are in all other aspects of social responsibility.

Bennis: When you think of our society's complexities and interdependencies — of all that goes into getting breakfast cereal or a slice of bread on the table in the morning in millions of American households — you wonder how any individual participant in that system can have any sense of commitment and responsibility. How can we attain it in today's world?

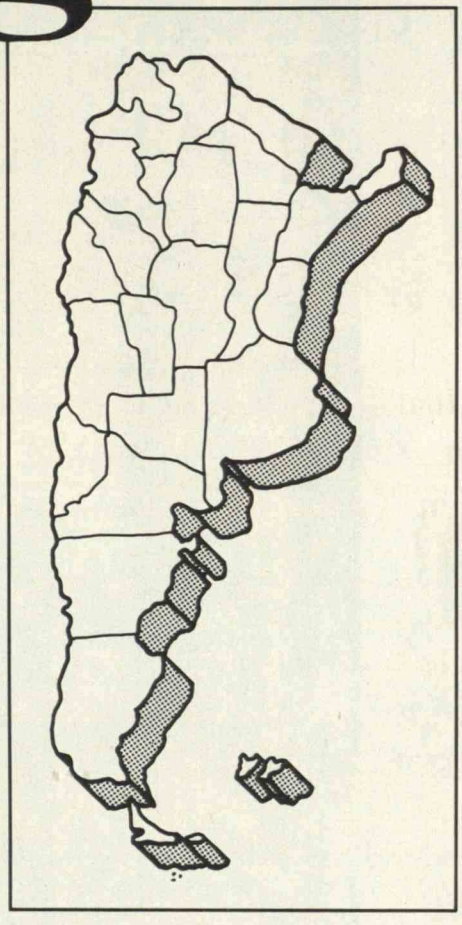
Hayes: I'm not sure I know exactly how to give a person a sense of responsibility. The fact is that people are surrounded by inconsistencies related to responsibility, and one of the first steps ought to be to analyze and dispose of some of these. For instance, when I pay taxes, if perchance I don't pay right on the day they are due, the government is very efficient in coming after me and saying that I'm penalized X per cent because I didn't pay on the due date. But when the government owes *me* the money, it turns around and says that it does not owe me interest, and I have to wait a month before I get the money. Then I say to myself: "Wait a minute. Doesn't this work both ways?" Both big government and big organizations have failed to inculcate a sense of interdependency in their organizations, and from their organizations to their customers.

Bennis: I can't argue with that. But the predicament you raise — that of responsibility and commitment — won't go away merely by an analysis of inconsistencies. The dilemma gets down to the questions of responsibility to whom and under what conditions. What leaders face today (or try not to) *within* their own organizations is a "new populism," the eclipse of community, an excess of pluralism, a loss of consensus among constituencies that go their separate ways — ways that are more often than not conflicting and volatile. These same leaders face another set of interdependencies with an equally volatile and turbulent set of expectations. I refer to — and those are only a fraction — regulators, citizen lobbies, media, consumer groups, suppliers. How can leaders be responsible to these diverse interests and discordant voices?

Hayes: This predicament — responsibility to whom, as you phrase it — means that the leader has to make tough decisions, has to decide which constituencies to neglect and even reject and which to support and when. And these tough choices have to be made without all the information and certainty one would like to have. That means taking risks under uncertainty, the most difficult choices of all.

I think this sense of risk-taking is now being compromised by the question of responsibility. Leaders become sensitive to the hundreds of thousands of people whose destinies they carry with them. Today, if leaders think about these thousands, they may not make a particular decision because they don't want these people to suffer. So rather than take a strong leadership position, leaders choose to remain silent or to take the safer course of lower risk. If you look back to the depression of 50 years ago, leaders were faced with two much clearer options: risking new initiatives or giving up and starving. Great entrepreneurs who chose the new initiatives came out of that generation into leadership. □

The New Argentina.



Everyone is talking about the *new* Argentina.

International leaders like Sunao Sonoda, Japan's foreign minister; President Francisco Morales Bermudez of Peru; Count Otto von Lambsdorff, minister of economics for West Germany; King Juan Carlos and Queen Sofia of Spain; and Willibald Pahr, Austria's minister of foreign relations—all recent visitors.

Prominent guests like David Rockefeller, chairman of the Chase Manhattan Bank; Michael Wilson, Canada's minister of foreign commerce, and Jack Spitzer, president of the Anti-Defamation League of B'nai B'rith.

And it's easy to see why.

Look at the great natural beauty of Argentina, ranging from the snow-capped Andes to the rich farming land of the Pampa. Frankly, it's a country of almost unlimited agricultural, mineral and forest resources.

And the streets of Buenos Aires, its capital of more than 8 million people, and other Argentine cities are peaceful and safe once again for citizens and tourists. The dark night of domestic unrest and chaos is over.

William D. Rogers, the former U.S. assistant secretary of state for Latin American affairs, contrasting his visit to Argentina in 1979 with one in 1975, said: "Nowadays, we live in another atmosphere."

That *new* atmosphere is everywhere.

Argentina has always been a cultural center of the Americas, and once again, the famous Colon Theatre is the busy hub around which the musical and dramatic life of Buenos Aires revolves.

Leading musical ensembles like the Hamburg Philharmonic Orchestra conducted by Aldo Cecato, the New York Philharmonic led by Zubin Mehta, and the Zurich Orchestra as well as famous stars like the internationally-acclaimed Italian tenor, Luciano Pavarotti, are featured. This year, Buenos Aires will celebrate its 400th anniversary with a year-long festival of the world's greatest music and musicians.

Argentina's economic future is equally bright. Net reserves in foreign exchange are $10 billion—compared with only $20 million in 1976. The balance of payments surplus for each of the last two years has been $2 billion.

Argentina's economic infrastructure continues to be expanded and strengthened. It is the leading Latin American country in nuclear development with a plant at Atucha completed and another at Embalse under construction. Four more electric-nuclear plants will be built by the year 2000. The billion-dollar Salto Grande hydro-electric dam between Argentina and Uruguay is already working.

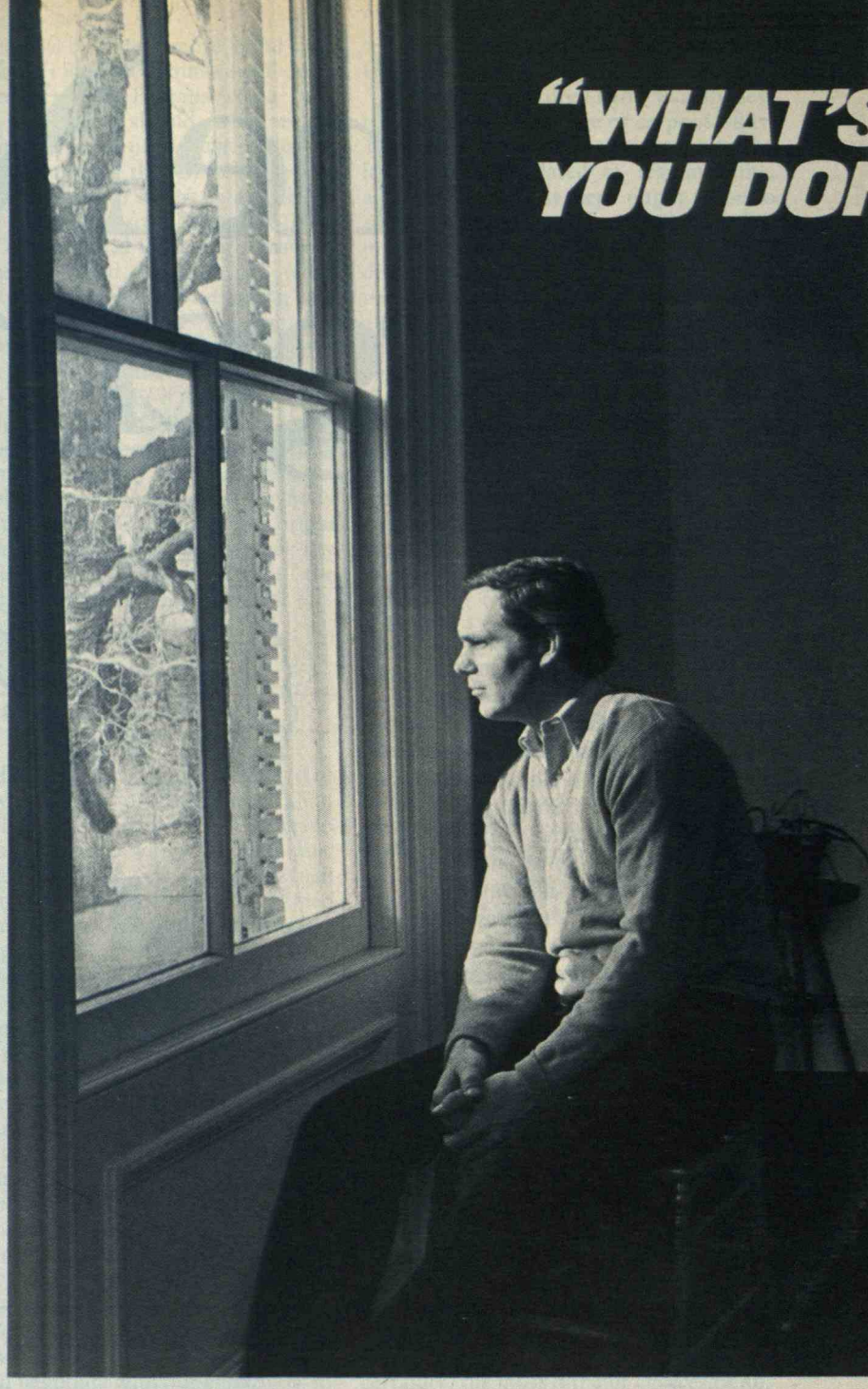
The World Bank and the Inter-American Development Bank have approved loans of $420 million to help finance the $3.8 billion Yacyreta hydro-electric project on the Parana River along the Argentine-Paraguay border.

With its extensive on- and off-shore oil fields, Argentina expects to produce all of its own petroleum by 1982. What's more, the 1978-79 Argentine wheat harvest was 52.8% higher than the previous year. And industry is up 16.6% over last year.

As former U.S. Secretary of the Treasury William Simon said of Argentina following his recent trip: "In the past three years, it has seen more light than the previous thirty. And that is something seldom known in history."

The people and the government of Argentina are just as optimistic about the next 30 years. A new spirit is alive in Argentina—a spirit of vitality, determination and confidence in a better future for every citizen.

The Embassy of the Argentine Republic, 1600 New Hampshire Avenue, NW, Washington, DC 20009



It starts out innocently enough.

A man tunes in a football game and tunes out his wife's attempts to be heard.

A woman gets so wrapped up in her problems she barely listens as her husband talks about his own.

And before long, without even realizing how it came about, a deadly silence starts to grow between them.

The fact is, listening, like marriage, is a partnership; a shared responsibility between the person speaking and the person listening. And if the listener doesn't show genuine interest and sensitivity to what's being said, the speaker will stop talking. And the communication will fail.

Which is why we at Sperry feel it's so critical that we all become better listeners. In our homes. And in our businesses.

We've recently set up special listening programs that Sperry personnel worldwide can attend. And what we're discovering is that when people really know how to listen (and believe us, there's a lot to know) they can actually encourage

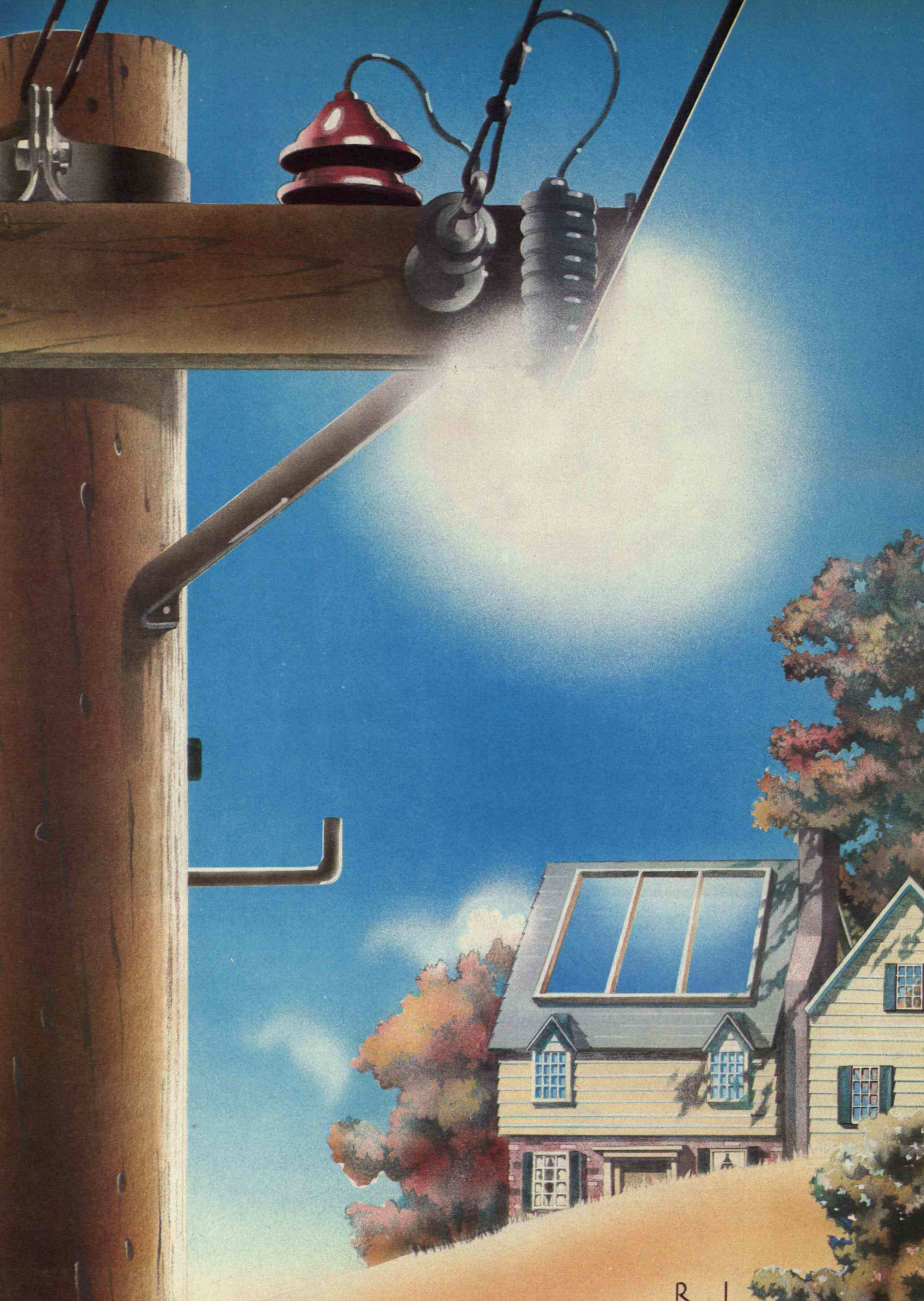
the speakers to share more of their thoughts and feelings, bringing everyone closer together.

Which is of great value to us when we do business.
And perhaps even greater value when we go home.

SPERRY

We understand how important it is to listen.

Sperry is Sperry Univac computers, Sperry New Holland farm equipment, Sperry Vickers fluid power systems, and guidance and control equipment from Sperry division and Sperry Flight Systems.



Solar Heating and the Electric Utilities

by
Modesto A. Maidique
and Benson Woo

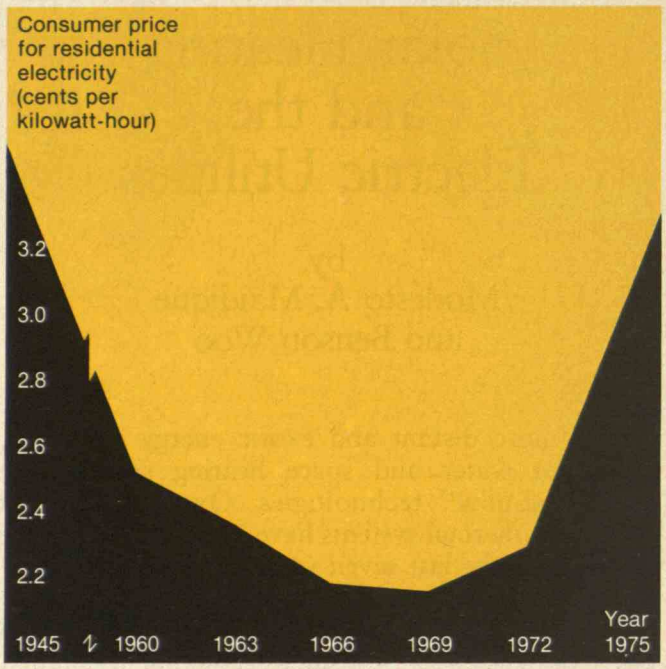
Unlike more distant and exotic energy prospects, solar hot water and space heating systems are "here-and-now" technologies. Over 200,000 of such solar thermal systems have been installed in the U.S. during the last seven years, at least in part because of recent federal incentives — tax credits of 20 to 30 percent — which in many cases have reduced payback periods to the point of economic feasibility. (Tax incentives of 55 percent have been enacted in California, and the Crude Oil Windfall Profits Tax increases the federal tax credit to 40 percent.)

Despite drawbacks that include sizeable capital investments, nonstandardized equipment from a new industry replete with firms of little experience and questionable longevity, and the intermittent nature of the sun as a source of power, solar thermal heating seems here to stay. Among its many effects will be substantial changes in the electric utilities' traditional role as a centralized provider of energy. The widespread use of solar thermal energy systems poses a novel challenge for utility planners. The changes will stem from the fact that occasionally at night and on cloudy days, solar users with inadequate storage capacity will be forced to rely on conventional energy sources — electrical resistance heating, oil, or gas. Thus, while the average electricity demand may be reduced, infrequent demand peaks may be very high. Major concerns of the industry include the adverse effect of solar thermal heating on revenues from the sale of electricity, and the probable need to maintain or even increase high levels of generating capacity.

In addition, because solar heating involves the unregulated distribution of an alternative energy source, the utilities fear that proposals to build new fossil-fuel or nuclear power plants might be compromised. As one utility consultant sees it, "The utilities want to remain in the driver's seat for determining the mix of energy sources."

The nation's electric utilities have the credibility, skills, resources, and organization to spur a solar-heating boom. And it is in their own — and the nation's — economic interest that they do.

Illustration: Roger Leyonmark



Changes in the average price of electricity in the U.S. from 1945 to 1975. The increases in consumer electricity price since 1969 are largely due to the sharp rises in the costs of replacing and operating plants and equipment. Note that the chart understates the real cost escalations, since the figures are based on historical costs. *(Data: Statistical Abstract of the United States, 1977)*

There are three basic ways in which the electric utilities can respond to the proliferation of user-owned solar thermal energy systems:

- ☐ Act to slow down or eliminate the use of solar energy;
- ☐ Do nothing;
- ☐ Encourage the economic use of solar heating.

The first two alternative strategies are essentially shortsighted and no longer appropriate. The third alternative, with appropriate rate reform, is both the rational choice for most utilities and in the national interest, considering the Carter administration's goal that solar energy supply 20 percent of the nation's total energy by the year 2000.

The advent of solar energy, however, signals the need for fundamental changes in the utilities' operating strategy. And any consideration of alternative strategies to deal with solar energy must also address the broader problem of the new industry economics.

The New Utility Economics

To understand the magnitude of the economic problems that the electric utilities now face and how solar heating could be part of a solution, one must first understand how they have been able to operate profitably under regulation.

Electric utilities are monopolies that provide electric service to customers on demand within specified service territories. This monopoly power is presumed necessary to ensure economies of scale in the expensive generation, transmission, and distribution facilities needed to provide reliable electricity.

The utilities are regulated by state public utility commissions (PUCs), which among other functions set the rates utilities are allowed to charge for electricity. Rates are based characteristically upon the value of plant and equipment in service, known as the "rate base." The PUCs establish a "fair" limit on the return on capital the utilities may earn on their rate base.

Because of the limits on their rates of return, the utilities have historically added to their capacity to generate electricity to increase their rate base and maximize absolute profits. This strategy was attractive as long as the cost of capital needed to add capacity remained lower than the rate-of-return ceiling set by the PUCs, and the marginal cost of new capacity was lower than average historical costs.

Today, however, these preconditions are in jeopardy. Driven by inflation, lenders are pushing the cost of capital toward and above the allowed fair rate of return; costs of additions to capacity have become greater than average costs of existing capacity. It is obviously unattractive to commit capital resources to an industry in which capital costs are higher than the allowed rate of return. The utilities are regulated monopoly suppliers of electricity, but they are also privately held business entities committed to producing a competitive rate of return on investors' capital.

Professors Robert Leone and John Meyer of the Harvard Business School have characterized the present dilemma of the electric utilities as one common to a wide variety of manufacturing and service industries, such as steel, paper, and airlines. The production costs in all these industries follow a U-shaped trend over time (*see the graph above*). On the left-hand side of the U-shaped curve, the costs of an industry decline with time because of technological improvements, increasing economies of scale, and efficiencies resulting from "learning by doing." When costs are declining in this fashion and demand is increasing at a predictable rate, the risk of investment in new facilities is minimal.

As a result, industries characterized by declining costs tend to favor strategies that stress expanding production capacity in anticipation of growth in demand. For decades the utilities followed just such a "capacity strategy."

But recently, returns on investment have de-

creased because of inflation, the increasing difficulty of raising capital, and the added costs of meeting new regulations. These costs have tended to outpace the capacity-related benefits of new equipment — as shown by the right-hand side of the U-shaped curve. A continuing decline in return on investment tends to make the economics of new plants and equipment increasingly unfavorable compared with those of old capacity. Under such conditions, the only attractive strategies for growth involve small-scale capital additions, and then only as demand actually materializes. But uncertainties in demand, such as the electric utility industry has experienced during the past five years, have also called strategies that add capacity in anticipation of growth into question.

In the 1950s and 1960s, when total kilowatt-hour sales grew consistently at rates of 9.3 and 7.4 percent, respectively, managing the growth of an electric utility was relatively straightforward. Electricity sales boomed, largely because of the decreasing price per kilowatt-hour. Lower prices were possible because the costs of new capacity were lower than the average historical costs of old capacity. As a result, the utilities developed a distinctive competence in financing, building, and operating large-scale electric generation, transmission, and distribution facilities. However, they failed to develop a similar level of competence in marketing, research and development, and customer service (which became routine).

But this strategy of adding capacity and simultaneously stimulating demand is no longer viable. Other strategies must now be considered because of the impact of components producing the right-hand side of the U-shaped cost curve:

☐ Increasing fuel costs, especially the phenomenal rise in the price of fuel oil.

☐ Rapidly rising costs for new fossil-fuel-based capacity. For example, new capacity can be built by Commonwealth Edison today at not less than $825 per kilowatt. This is over twice the original cost of equipment built in the 1940s, which should now be replaced, and it is almost *six times* the average book value of such equipment. The replacement cost of nuclear-based capacity is even higher — in the range of $1,000 to $1,500 per kilowatt for Commonwealth Edison.

A utility must have enough capacity to meet the highest demand of its customers for electricity and to preclude the possibility of blackouts, but much of this capacity is unused a great deal of the time. The reason is simple: most people turn on their electrical devices during the same period. No economic incentive exists for consumers to shift their consumption to periods of low demand such as the early morning hours. But the need to recover investment in new plant and equipment — idle or working — is unyielding and reflected in higher rates for all users.

The demand for additional capacity has waned since the 1973 oil embargo because of higher energy prices and the new energy conservation ethic. The national consumption of electrical energy dropped slightly in the 1970s, thus reducing the utilities' load factors (the average percentage of peak capacity that is actually being used). But in a much tougher regulatory climate stimulated by environmental concerns as well as rising prices, the utilities found it politically difficult to plead before their regulatory commissions for higher rates to compensate for stagnant demand and regulatory lags. Though utilities are permitted to automatically pass on to consumers much of their higher fuel costs, regulatory red tape has prevented quick relief and exacerbated cash-flow problems.

Despite these problems, electricity prices have gradually stabilized in recent years, and the demand for electricity has begun to climb again, now surpassing that of pre-embargo days. Utilities must again consider expanding capacity. But they are under political pressure to reduce dependence on oil, and alternative capacity options have become elusive. Foes of nuclear and coal have mounted increasingly successful campaigns to slow or halt the growth of these energy sources, voicing economic, environmental, and safety concerns. The result has been a "nuclear stalemate," and many observers — including the authors of the Energy Project report of the Harvard Business School — are only moderately optimistic for rapid increases in the use of coal.

In addition, most utility common stocks are selling well below book value, because many potential investors have shied away from these securities. High interest rates discourage utilities from entering the bond market. All these factors are acting to constrain planning and delay new construction.

Solar Heat, Load Factors, and Rate Reform

The spectre of solar-related irregularities in electrical demand is of special concern to the electric utilities. Utility costs are very sensitive to changes in peak demand characteristics. The higher the peak demand, the higher are a utility's fixed and operating costs. The industry presently operates at a load fac-

tor — the ratio of average to peak load — of about 62 percent. If average load fails to grow along with the peak, the return on building and maintaining occasionally used peak generating equipment will drop.

Some utility planners fear that widespread adoption of solar heating would decrease the load factor. Solar water heaters typically replace gas- or oil-fired water heaters (except in a few regions where electric water heating predominates), but they generally use electric resistance heating for backup. Thus a utility serving an area where solar water heating is popular can expect high peak loads during periods of cloudy, dark weather.

A study of solar-heating customers made by H.G. Lorsch at the Franklin Institute Research Laboratories quantifies these problems, making clear the reasons for the utilities' concerns regarding on-site solar heating. Among his findings:

☐ The solar heating customer has a load factor that is 40 to 50 percent lower than that of a conventional electrical resistance heating customer.

☐ Demand-related and customer-related costs of serving a solar-heated home are equal to those of serving a conventional, electrically heated home.

☐ Present electric rates would not recover the costs of serving solar homes.

The impact of solar heating will be especially severe for utilities whose peak loads occur in winter. Summer peaks are largely caused by air-conditioning loads; winter peaks, by heating and lighting. Therefore, with current rates, winter-peaking utilities would be affected more severely by solar heating systems than would summer-peaking utilities. A summer-peaking utility's annual peak is likely to occur on a hot summer day when solar heating systems can fulfill all hot water needs and when space heating is unnecessary. But a winter-peaking utility at its peak is more likely to experience heating loads coincident with cloudy or dark periods, when solar output is nil.

Solar-heating customers will therefore increase demand for electricity in the winter, and substantial adoption of solar heating may even transfer peaks from summer to winter. Our study of one Northeastern summer-peaking utility showed that if 20 percent of the utility's residential customers adopted solar hot water and space heating, peak demand in the winter would exceed the summer peak. We would predict an even greater shift if we were to define the market more broadly: we included only suburban family homes in our analysis.

Such redefinitions of demand imply costly and difficult modifications of utility facilities and operating plans. But because they are regulated, utilities lack the freedom to accommodate such costs by simply raising prices. An example of regulatory constraint can be seen in the 1976 experience of a Colorado utility that insisted on receiving revenues from solar users equal to the cost of their service. It requested the PUC to approve a surcharge of $40 per month for customers using auxiliary electrical energy on a standby basis if they used any utility electricity during the month — a policy that would be a major barrier to solar heating in Colorado. The PUC has not yet authorized the surcharge, and is unlikely to do so. Similar experiences may emerge in other states as utilities attempt to recapture their full costs of serving solar users.

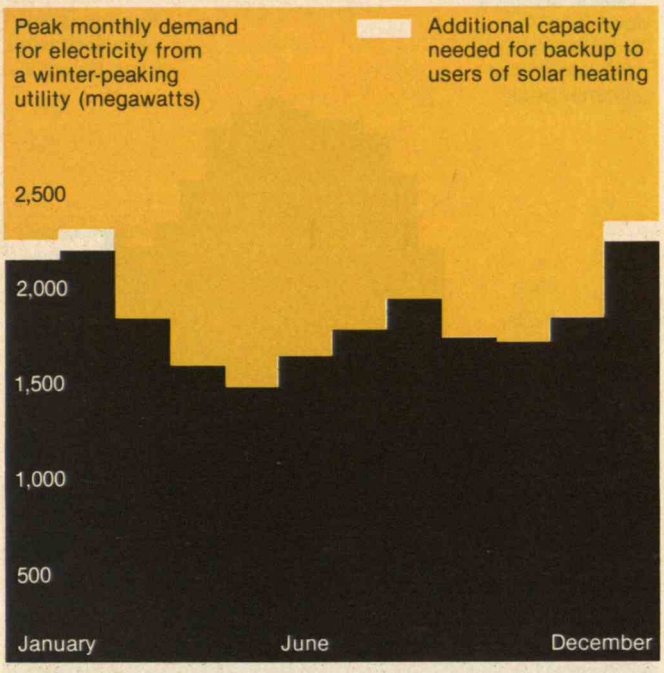
The real issue is not the utilities versus solar customers, but whether nonsolar customers should subsidize solar customers. Electric utilities ultimately must be permitted to recover their costs, but a general rate increase to favor the growth of solar heating would affect conventional customers more adversely than solar-heating customers. The existence of such a conflict of interest makes the issue one best weighed and decided by government.

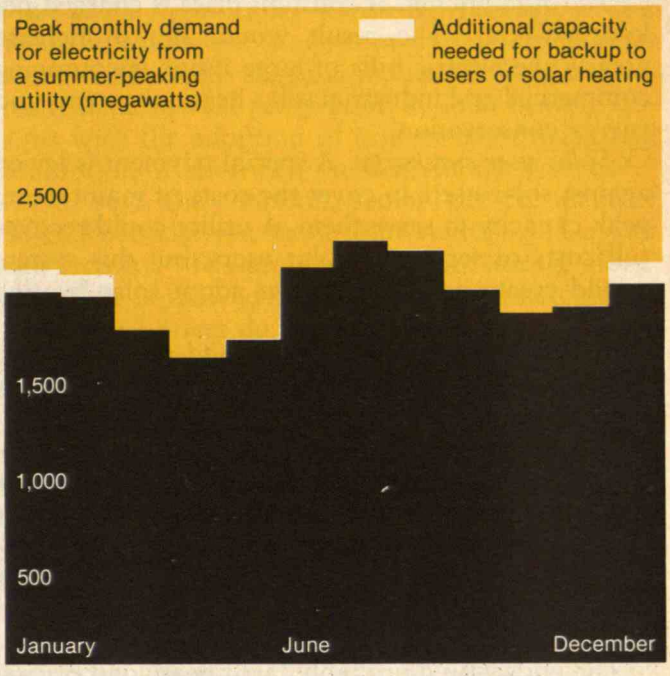
Rate Reform: Pros and Cons

Modifying the way in which electricity rates are structured is the simplest of the various load-management techniques available. Put simply, the rate structure has the potential to encourage the shift of the backup demand of solar users to off-peak hours (utilizing a means of storing heat), which would then allow a utility to realize fuel savings and to defer increases in generating capacity.

The two types of rate structures commonly used today in the U.S. are the *declining-block*, or *average cost*, rate and the *energy demand*, or *Hopkinson*, rate. Under declining-block rates, the price of additional "blocks" of electrical power becomes less expensive than the previous "block." The Hopkinson rate is similar to the declining-block rate except that it includes a charge for the amount of peak capacity a utility must maintain to service that customer. It thus tends to encourage customers to shift their consumption from peak hours. But a customer's peak load does not necessarily coincide with the utility's overall peak demand.

Shortcomings of both rate structures are well known. They encourage the consumption of elec-





How will the use of solar hot-water heaters affect the electric utilities? A typical utility that experiences its peak load in the winter *(left)* would be affected more severely by widespread use of such solar devices than one that peaks during the summer *(right)*. New solar customers would directly contribute to the annual peak of a winter-peaking utility, thus creating the need for new capacity. A summer-peaking utility would not be likely to develop the need for new peak capacity, but would experience an increased peak load during the winter months.

tricity by lowering unit prices as consumption increases without regard for *when* the electricity is consumed. As a result, they discourage the shifting of demand away from peak periods, because consumers responsible for additional peak demand are undercharged while off-peak consumers are overcharged. The result has been abnormally fast growth in peak demand and a need for costly additions to capacity. Fortunately, the peak demand for solar homes is likely to occur during off-peak hours — a not undesirable characteristic — and the Hopkinson rate, if more widely used, would tend to encourage the solar option. But it would not resolve the utilities' problems.

Other alternative pricing schemes would better serve to influence solar users and provide equitable charges. A utility might petition its regulator for such rate structures as:

☐ *Rate inversion*. Under this plan, the first kilowatt-hours purchased by any user are cheapest, and prices increase with additional consumption. The effect would be to encourage solar heating systems and conservation, but there would be no incentive to shift demand.

☐ *Peak-load (time-of-day) pricing*. High rates are charged during peak-demand hours, lower rates during off-peak hours. The effect would be to level peaks, since consumers would seek low rates. The impact on solar heating depends on the availability of low-cost storage.

☐ *Flat-rate pricing.* A constant price is charged per kilowatt-hour. The result would be to increase greatly the electric bills of large users, encouraging commercial and industrial solar heating systems and energy conservation.

☐ *Solar user surcharge.* A special payment is levied against solar users to cover the costs of maintaining peak capacity to serve them. A utility could recover full costs of service to solar users, but this system would create a disincentive to adopt solar heating systems.

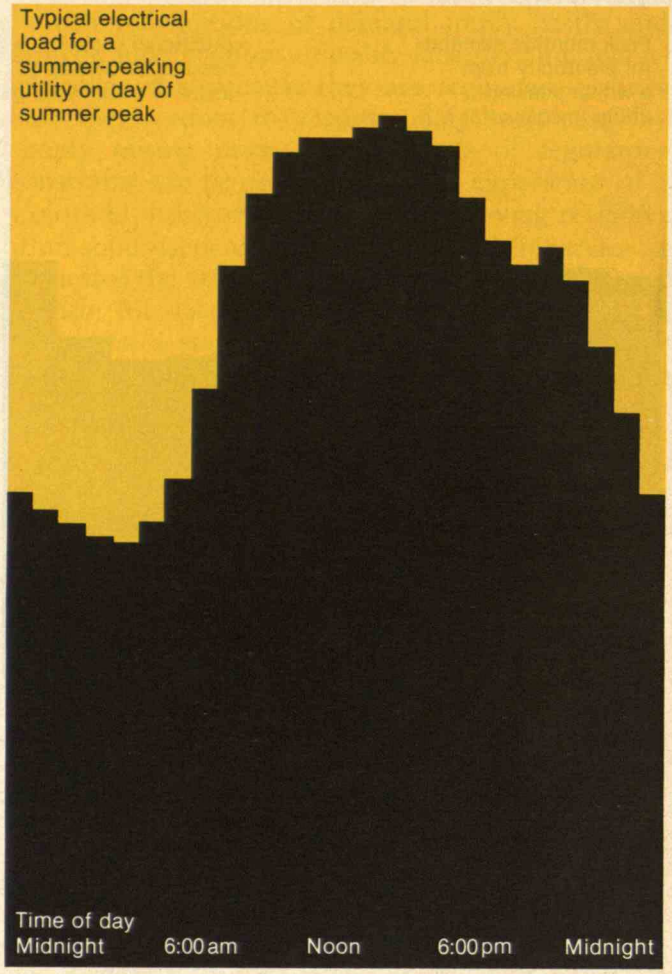
☐ *Interruptible service (direct load management).* Under this management plan, electric utilities are allowed to deny customers 220-volt electricity (typically used for water heaters, driers, large air conditioners, and space-heating systems) during periods of peak demand but are required to charge a lower rate in return for the inconvenience. If service interruptions were frequent and annoying, customers would be likely to install solar heating systems and practice conservation.

The PUCs would probably favor peak-load pricing since this type of rate tracks marginal costs most closely. Results obtained by the Connecticut Public Utilities Control Authority in a recent one-year peak-load-pricing experiment showed that customers opted for cheaper off-peak electricity whenever possible, shifting substantial consumption away from the peak periods. The result was that the load factors of test-group customers were significantly higher than for those paying on the conventional declining-block system — possibly enabling utilities to defer expensive additions to capacity and helping them adjust to the effects of solar heating.

There are drawbacks to using any kind of rate reform as a vehicle for shifting load, however. The major problem is that rates have only an indirect influence on consumption. Customers might use electricity as backup during cold, cloudy periods regardless of the price penalties. And it is unclear how many customers would participate in voluntary arrangements such as interruptible service or peak-load pricing.

A Brief, if Heated, Nonsolar Aside

Some economists contend that peak-load pricing would make possible the use of *nonsolar* thermal storage systems heated with cheaper off-peak electricity, and that this option might in fact be less costly than the use of off-peak electricity to supplement solar collectors (*see "Electric Heat: The Right*



The variation of electrical load on a typical summer-peaking utility on the day of summer peak. The use of solar hot-water heaters would be most effective on such a day and might even reduce the peak load. But the utility would still have to maintain enough reserve capacity to meet the needs of these solar customers — as well as nonsolar customers — during periods when sunlight isn't available.

Increments of electricity use (kilowatt-hours)	Cost per kilowatt-hour (dollars)
Declining Block Rate (residential customers)	
15 or less per month = $2.06	.1373
Next 35	.0593
Next 50	.0456
Next 50	.0371
Next 150	.0340
Next 84	.0309
Next 616	.0233
Additional use	.0160
Hopkinson Rate (commercial and industrial customers)	
10 or less per month = $3.15	.3150
Next 490	.0795
Next 500	.0655
Next 500	.0552
Additional use	.0337
Customer Demand (kilowatts)	
First 10	0.00
Additional demand; July to October	5.84
Additional demand; November to June	4.85

A comparison of typical rate structures for an oil-burning utility company in New England. Under the declining-block rate structure, relatively small additional blocks of power become less expensive; under the Hopkinson rate structure, relatively large blocks of power become less expensive and an additional charge is levied for demand in excess of 10 kilowatts.

Price at the Right Time," December/January, 1980). Would the widespread adoption of time-of-day rates mean a setback for the solar industry? Could utilities really deter market penetration by solar heating systems with the adoption of time-of-day pricing and promotion of electrified thermal storage systems?

No, says Gary Nelson, senior vice-president of Solar Thermal Systems (a joint venture of Daystar and Exxon): "The problem with the 'storage alone' argument is that advanced storage technologies at economical prices do not exist at this time. . . . The present storage capacity technology with 24-hour capability would mean a fairly large expenditure for the homeowner." In any case, the argument for time-of-day pricing does not hinge on this issue. The electric utilities needed time-of-day pricing even *before* the threat from solar energy materialized. The implications of solar energy have only accentuated, rather than created, the need for rate reform and load management.

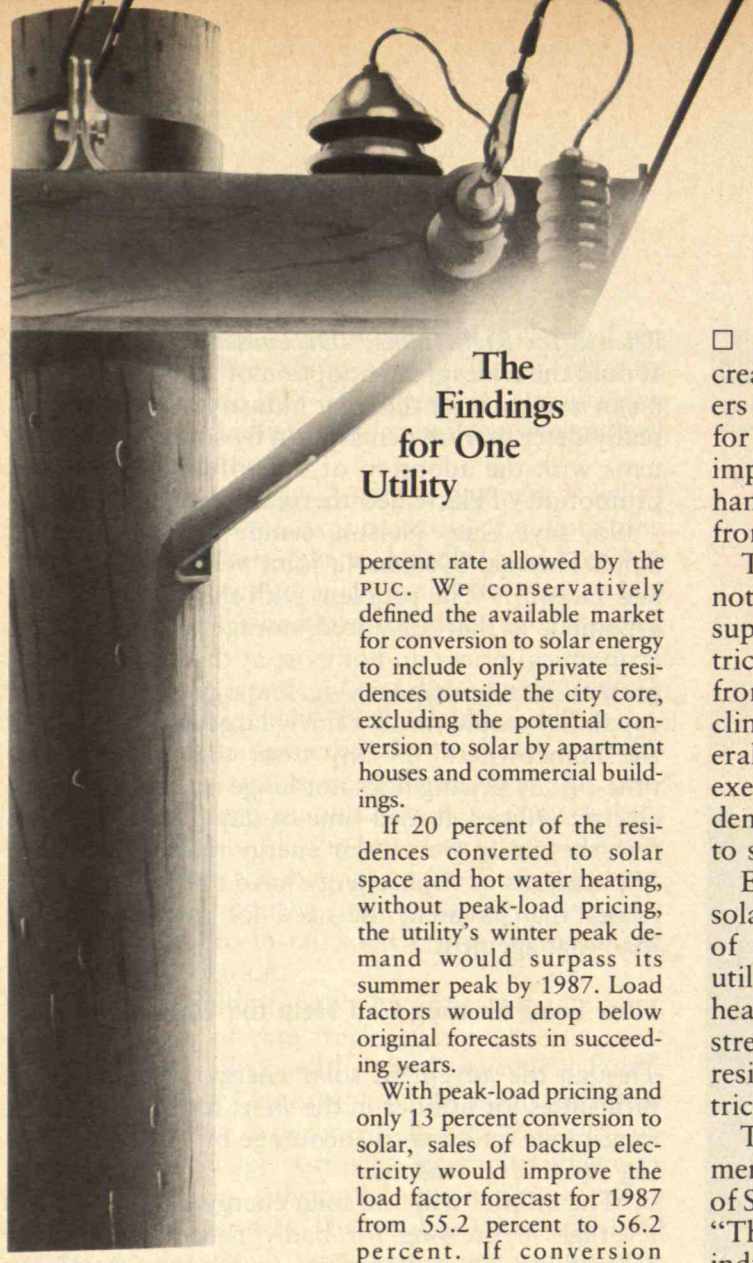
How Solar Heating Can Help the Utilities

Though the advent of solar energy promises some difficulties for utilities in the short term, it is in their long-range interests to encourage on-site solar heating for several reasons:

☐ The utilities will find solar energy a new source of leverage in pressing for badly needed progressive rate reform. The government, on the other hand, can benefit from the support of the utilities to make politically popular progress in solar commercialization.

☐ Solar energy represents opportunities for the utilities to avoid investments in new capacity that may never be recovered (on a discounted cash-flow basis) and to build capacity in small increments as demand requires. The responsibility for obtaining funds to invest in energy capacity would shift from the utilities to their customers as the public seeks to install on-site solar thermal generation. (Ironically, utilities should avoid investing in large-scale, centralized solar thermal energy facilities such as power towers, which can provide only *part-time*, capital-intensive capacity that in turn must be supplemented by more capital-intensive, nonsolar capacity.)

☐ Solar heating could be considered a means for utilities to meet their responsibility to satisfy the energy needs of their customers. The shortfall created by delays in putting new capacity on line could be mitigated by widespread use of solar heating systems.



The Findings for One Utility

We investigated what the widespread adoption of solar residential heating could mean for one medium-sized Northeastern electric utility, which uses mostly oil-fired generators and has one nuclear unit. The utility serves a large metropolitan area with a demand that has historically peaked in the summer, including a suburban area that is heated generally with oil.

Since the oil embargo of 1973, the firm has not done well financially, and in recent years it has failed to generate enough cash to pay its dividends without resorting to external debt. Adjusting reported profits for replacement costs would have dropped the stockholders' rate of return to 4.3 percent for 1978, far below the 13 percent rate allowed by the PUC. We conservatively defined the available market for conversion to solar energy to include only private residences outside the city core, excluding the potential conversion to solar by apartment houses and commercial buildings.

If 20 percent of the residences converted to solar space and hot water heating, without peak-load pricing, the utility's winter peak demand would surpass its summer peak by 1987. Load factors would drop below original forecasts in succeeding years.

With peak-load pricing and only 13 percent conversion to solar, sales of backup electricity would improve the load factor forecast for 1987 from 55.2 percent to 56.2 percent. If conversion reached 33 percent, the load factor would improve to 57.1 percent. By 1990, additional annual revenues from solar backup sales would reach $4.2 million with 20 percent conversion (at 1.5 cents per kilowatt-hour), and $16.9 million with 40 percent conversion (at 3 cents per kilowatt-hour).

Should the firm also decide to try its hand at marketing solar equipment, we estimate that it could realize a profit of $1 million on additional revenues of $21 million in 1985, assuming it held a 20 percent share of a market consisting of 20 percent of its customers. Considering the limited investment needed to enter the solar equipment business, the company's break-even market share requirements are modest. — *M.A.M. and B.W.* □

□ Assuming the adoption of time-of-day rates, increased use of electrically assisted solar water heaters by customers who presently rely on fuel oil or gas for heating would generate increased revenues and improve load factors. Rising oil and gas prices enhance the likelihood that solar heat users would shift from oil or gas to electricity for backup.

These ancillary financial benefits, however, would not be shared equally by all utilities. Firms that also supply natural gas and those with large bases of electrical heat customers would find that the benefits from solar heating might be counterbalanced by declining sales in other parts of their business. In general, utility people are optimistic. As one utility executive explained, "We are not concerned about demand reductions because we will always be able to sell all the extra energy we can produce."

Electric utilities that participate directly in the solar industry will realize additional profits. Because of their size and experience with financing, the utilities have every chance for success in the solar heating market. They also have a uniquely valuable strength — a long-standing link with the nation's residential, commercial, and industrial users of electricity.

The utilities could have a key role in the development of solar heating. Says Robert Ladner, manager of San Diego Gas & Electric's (SDG&E) solar effort: "The utilities can bring some credibility to the solar industry just by their presence. . . . We can also help speed the development of the industry. . . . The electric utilities could disseminate information on technical quality and maintenance and help improve the standards for everyone."

One can imagine a future scenario in which a utility representative, a "house doctor," would prescribe an optimal combination of conventional, solar-heating, and conservation measures for individual customers, supported by computer analysis of the impact of additional solar customers on utility output. The utility could arrange the financing, supervise installation, and guarantee and service the work. Most utilities do not presently have a cadre of employees with the requisite skills — a situation that could be rectified with only modest training. Utilities are already experienced in servicing large groups of customers; economies of scale could be achieved in such training programs. According to John Cooper, vice-president of Pacific Gas and Electric, "The utilities are in an excellent position to provide both solar and conservation analyses to our residential as well as our commercial/industrial customers."

How Will Utilities Sell Solar?

But the time for making a plunge into solar is dwindling. If a utility decides to promote the use of solar energy, it should do so aggressively, to prevent damage to market acceptance from some of the classic performance problems of the nascent industry.

A recent performance evaluation of 100 solar water heaters in New England demonstrated that only 15 of the installations functioned well and without breakdowns, while 27 produced little or no energy savings when operating. Problems were due primarily to faulty installation. Clearly, reaping the rewards from sales of solar equipment requires proficiency in marketing and customer service. However, the utilities do have the advantage of established reputations.

Recent actions by government agencies have constrained utility involvement in solar heating on antitrust grounds. For example, in 1978 SDG&E undertook a marketing program that resulted in the sale of 43 solar domestic hot water systems. Prior to the sales, SDG&E requested bids from over 60 solar equipment suppliers, but many small manufacturers feared the utility would monopolize the solar field. They demanded — and won — legislation that now prohibits California utilities from directly selling solar equipment. At present, the state's PUC and its energy commission are conducting a joint investigation to determine the role utilities should play with respect to solar energy, and whether such activities should come under the jurisdiction of the PUC.

Utility strategies for meeting the challenge of solar heating are sharply limited by PUC regulations. Thus, a large part of the responsibility for determining the ultimate role of the utilities rests with the PUCs. The PUCs must become innovative intermediaries between the utilities and the solar industry if the U.S. is to exploit this technology to help achieve its solar-heating goals. It would be truly unfortunate if SDG&E's recent experience with its PUC dissuaded other utilities from supporting the solar option. □

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The authors benefitted from discussions with Professors Robert Leone and Robert Stobaugh of the Harvard Business School.

Dos and Don'ts for Whistleblowers: Planning for Trouble

by
Peter Raven-Hansen

Whistleblowing, or professional dissent, is often justified on moral grounds. Yet it can be lonely, unrewarding, and fraught with peril, so the would-be whistleblower should proceed with caution.

Most literature on whistleblowing, or professional dissent, addresses the moral and ethical questions of *whether* a professional should blow the whistle and the legal question of his right to do so without penalty. However, once a professional concludes that he or she is morally compelled to disclose information about fraud, corruption, mismanagement, or hazards that someone else has disregarded, suppressed, or falsified, there is still the question of how to do it. If the professional concludes, or is advised, that there is a legal right to blow the whistle, he still has to prove that he acted properly. Usually this turns on just how the whistle was blown.

Unfortunately, the typical dissenter blows the whistle, and thus complicates the case, before consulting a lawyer. This, therefore, is a plea — from a sometimes frustrated whistleblower's lawyer — for dissenters to act defensively and anticipate trouble.

There are a few basic rules for defensive whistleblowing:

- ☐ Focus on the disclosure itself, not on personalities.
- ☐ Use "channels" before going public.
- ☐ Anticipate and document retaliation.
- ☐ Know when to give up.

Focus on the Disclosure

Focusing on the disclosure is the most important yet most frequently forgotten "must" for whistleblowers. Although the primary ethical rationale for public dissent is the disclosure of vital information affecting health, safety, or general welfare, the typical whistleblower is often quick to personalize the issue. One reason is that she sometimes better understands what happened to *her* better than the information she discloses, which may involve unprovable professional judgments. It is often easier to point the finger at a "cover-up" than to prove an accusation.

Another reason this rule is often overlooked is

Portrait of a Whistleblower

Photograph: Ralph Mercer

that the whistleblower's personality frequently *is* part of the problem; it takes something of an eccentric, a maverick, or, perhaps in management's view, a "deviant" to risk alienating or embarrassing colleagues and employers. And even if the whistleblower is not a "difficult" personality, his employer will usually portray him as such to divert attention from the disclosure.

Would-be whistleblowers should carefully consider the reliability of the information; whether the information must be disclosed; who should disclose it; the best format for disclosure; and, especially, the need to avoid personal accusations, even when they are justified.

The information may consist of verifiable facts. This kind of disclosure is the easiest to consider, as it can be made without fear of immediate contradiction. Unfortunately, this type of information is rare. When the information concerns public health, safety, or environmental quality, it is likely to involve risk assessment, which is often more politics than science, and therefore involves more judgment than objectivity. In this respect, scientists and engineers may have more difficulty characterizing information than do professionals in cost analysis and budgeting, where the information is usually "harder" and therefore more easily judged.

At the opposite end of the spectrum is rumor — unsupported information from third parties. Here the rule is clear: don't blow the whistle on the basis of such information — it's "bad science" to release it. Of course, a professional who is convinced of a rumor's probable truth and concerned about its significance may feel ethically compelled to disclose it. But when the information consists solely of unconfirmed rumors, self-defense usually requires "swallowing the whistle."

Between these extremes lies the more common case: information that, though not completely verifiable, is nevertheless compelling. Again, what to do with such information varies with the circumstances. However, the courts have evolved a formula of sorts which provides some guidance. In securities law, courts are frequently asked to assess whether financial or business information is so germane that it must be disclosed to the stock market or would-be traders. The rule is that if reasonable investors would take it into account in making investment decisions, then the information is material. This rule can be applied with equal force in other areas.

Mandatory Disclosures

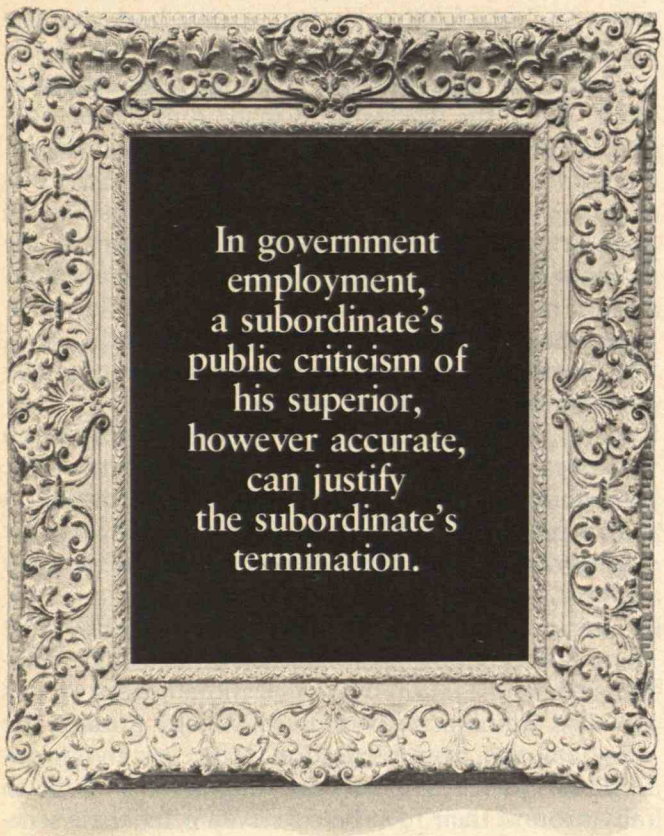
In theory, deciding to blow the whistle is easiest when the disclosure is required by law. Most professionals know, or assume, that outright falsification of budgetary or scientific reports required by a regulatory agency is unlawful. They therefore rightly conclude that to the extent they take responsibility for such reports, they have a duty to provide correct information. But the duty may go even further.

Federal criminal law makes it "misprision" of a felony (punishable by up to three years' imprisonment) to conceal and fail to report a felony committed by someone else. For example, persons who apply for a license to operate or construct a nuclear facility are required to submit their applications to the Nuclear Regulatory Commission (NRC) under oath. If an employee is aware that her employer has knowingly submitted false materials and she helps conceal the falsity with any act — no matter how innocent in the abstract — this consitutes a criminal act punishable by fine or imprisonment.

Setting aside the rare cases where criminal law mandates disclosure, there are many instances where disclosure to civil regulatory authorities is mandated by a specific statute. For example, the Energy Reorganization Act of 1974 requires any individual director or responsible officer of a power plant to inform the NRC of failures to comply with nuclear safety standards or of defects that could create substantial nuclear safety hazards.

Prohibited Disclosures

Just as there is information that a professional must disclose, there is information that must *not* be disclosed. Private-sector professionals are frequently constrained by sweeping promises of confidentiality that were signed at the time of employment and then



promptly forgotten. Such contractual obligations typically cover "trade secrets" as well as other proprietary data that might be helpful to competitors. Even if such obligations are not enforceable in court, breaking them may furnish a justification for firing.

Much information given to regulatory agencies is also subject to a statutory pledge of confidentiality and is, for example, exempt from disclosure under the Freedom of Information Act. Some federal statutes actually make it a misdemeanor for officials to disclose certain information for purposes other than those specified.

The unauthorized disclosure of classified security materials is clearly ill-advised and often unlawful. Yet much government information is inappropriately overclassified, sometimes for the very purpose of improperly keeping it from the public. Classified information sometimes even includes data such as procurement costs, budget overruns, and construction plans.

An even larger grab bag of information is informally "classified" as "official use only," "confidential," "eyes only," "draft," "preliminary," or some other imaginative phrase conceived to restrict circulation and disclosure. Such informal classifications have no statutory significance — disobeying them is not illegal — yet they can determine the outcome of a whistleblower's case. Disclosure of informally classified information can be branded as an act of "disloyalty" sufficient to justify a firing, or at least a black mark on a personnel record.

In a closed congressional session, for example, a public employee who disclosed military cost overruns was accused by his superiors of leaking "confidential documents." There was a clear implication of security violations. Only after the employee's dismissal did the agency admit that no security breach had occurred and that the released information was at most "confidential with a small 'c.' "

It is very important that would-be whistleblowers, after assessing the reliability of information they intend to disclose, consider any restrictions placed upon it. If there is the possibility of an informal or

statutory restriction, the professional would do well to search for an alternate unrestricted source of the same information. If this is not available, the would-be whistleblower should consider getting a legal opinion before continuing.

The Appropriate Discloser

Once a professional decides that information is reliable and must be disclosed, he still has to ask whether *he* should be the discloser. Is it his whistle to blow? Or is someone else formally responsible for it? Are there restrictions on his assigned activities that suggest that the information should come from another? Finally, would it be more credible coming from someone else?

In one case, a salesman of high-pressure steel tubes used by the oil and gas industry concluded that the tubing was dangerous because it had not been adequately tested. When the salesman brought this potential hazard to his superiors' attention, the product was withdrawn from the market and he was fired. A court subsequently ruled that the firing was lawful, reasoning that the salesman was "involved only in the sale of company products. There is no suggestion that he possessed any expert qualifications, or that his duties extended to making judgments in matters of product safety." The court, if not the employer, might have looked on the situation more favorably if the salesman had brought the problem to the attention of the engineering department.

Appropriate Format

The format in which the information should be disclosed varies, of course, with the particular information, but there are a few useful rules:

☐ A clear, *short*, summary of the information — describing what it means, why it is significant, and what should be done about it — is very important. Many professionals, particularly those trained in the sciences, believe that numbers speak for themselves and so are content to disclose raw data, lab reports, or statistics without comment, analysis, or summary. Such professionals often assume both that the recipient will read the information and that she is qualified to understand it. Neither assumption is valid. When the disclosure is made outside the normal chain of command, as is often the case, the recipient may not be technically qualified and the disclosure will be totally ineffective unless phrased in plain English. And even if the reader is qualified, she may not be willing to go through voluminous material or may feign ignorance. A clear one- or two-page summary, stripped of euphemisms and jargon, not only makes the disclosure more understandable but also more difficult to ignore.

☐ It is also helpful to specify how the information was obtained and to provide supporting materials. Describing the exact source of the information makes it more credible, as well as more difficult for superiors to claim that they could not have known about it.

☐ Verification of the information by outside sources or other professionals can obviously be helpful, and confirmation by a professional society lends an aura of objectivity that may help protect the whistleblower from retaliation. However, most professional societies have been inexcusably slow to rally around their members or even offer their services in a review or verification role. So instead the whistleblower most often turns to individual colleagues for verification. Unfortunately, there are many problems with this. The more people involved with the information, the greater the chance of a leak; verification may be only "fair weather"; and the colleagues may get into trouble.

☐ The disclosure's format should force management to go on record about the information. This might be achieved by specifying a reply date, providing an acknowledgment box, or sending copies to other recipients who might expect a response. The oldest response-generating technique in business and the law is simply to write, "I shall assume that you agree with this assessment and with its inclusion in the quarterly report to regulatory agency X unless I hear from you before January 10." Such language should be phrased as carefully and innocently as possible to force the recipient to go on record with-

Informal security classifications such as "eyes only," "draft," or "confidential" have no legal significance, yet they can determine the outcome of a whistleblower's case.

out seeming to throw down the gauntlet.

Avoid Name Calling at All Costs

One of the most important points in whistleblowing is to focus on the disclosure itself and avoid personalities or finger pointing. Personal charges often overshadow the disclosure and lead the whistleblower into personality conflicts. This rule applies even when the whistleblower believes that certain individuals are responsible for safety hazards, corruption, waste, or other nasty actions. The disclosure itself usually leaves a trail for others to follow to the miscreants. Let the recipient of the information come to her own conclusions.

Questions of intent and willfulness are questions of law about which the whistleblowing professional usually has no particular learning or expertise. Such personal accusations are best left to civil authorities and others better equipped to assess questions of fault and civil or criminal responsibility.

For example, an engineer employed by a federal regulatory agency discovered a serious omission from a safety report prepared by his agency. However, in reporting the omission to management, he characterized it as an instance of incompetence and deliberate cover-up by his immediate supervisor, and requested the supervisor's removal. Management, in a memorandum barely mentioning the original omission, transferred the whistleblower to "reduce tensions." By framing his disclosure in personal terms, this whistleblower had ignored the cardinal rule of whistleblowing.

Consider another reason for avoiding personalities. Accusations of fraud, deliberate concealment, reckless behavior, lying, negligence, and even mismanagement are serious — indeed, so serious that society has assigned them to a special class of professionals: prosecutors. Moreover, a precise body of law has developed around these terms, and unless the whistleblower is familiar with that law, it is likely that what she considers bribery, perjury, or even negligence does not coincide with the courts' definition of these terms. By personalizing her disclosure, therefore, she may unwittingly expose herself to a libel or slander suit or other legal entanglements.

Furthermore, even if legal problems do not result, antagonisms from personal accusations may effectively destroy a career. In government employment, for example, the Supreme Court has suggested that a subordinate's public criticism of his superior, however accurate, can justify the subordinate's termination because of its effect on working relationships.

Using Channels Before Going Public

Once the would-be whistleblower has evaluated the information and chosen an appropriate format, he must decide where to go with the disclosure. There are several reasons why a professional should *always* attempt to make the disclosure within channels before going public.

First, it might work. If an employer acts on the information, or relays it to appropriate civil authorities, the whistleblower has accomplished his objective with a minimum of exposure and a maximum of efficiency. The employer is presumably in the best position to evaluate and act upon the information, and should need less educating to understand the significance of a technical disclosure.

Second, the whistleblower may be required to try channels first. Federal agencies and other bureaucracies frequently require employees to act through a chain of command. Violation of such procedures, which are frequently unwritten but well-understood, may give cause for firing or, at the very least, provide ammunition for a personal attack on the whistleblower's motivation. For example, in the case of the tubular products salesman, the court, in upholding the firing, felt it important that the salesman had "bypassed his immediate superiors and pressed his views on higher officers."

Third, regardless of the legal consequences of going outside channels, the professional may, as a matter of personal loyalty, believe she owes management or her employer the "right of first refusal."

Finally, even if the professional concludes that he has no obligation to act within channels and that it would be fruitless, he may want to make a record of

having tried. This involves documenting the information and giving copies to as many people as possible. The larger the number of recipients, the more certain that at least one copy will survive in the files.

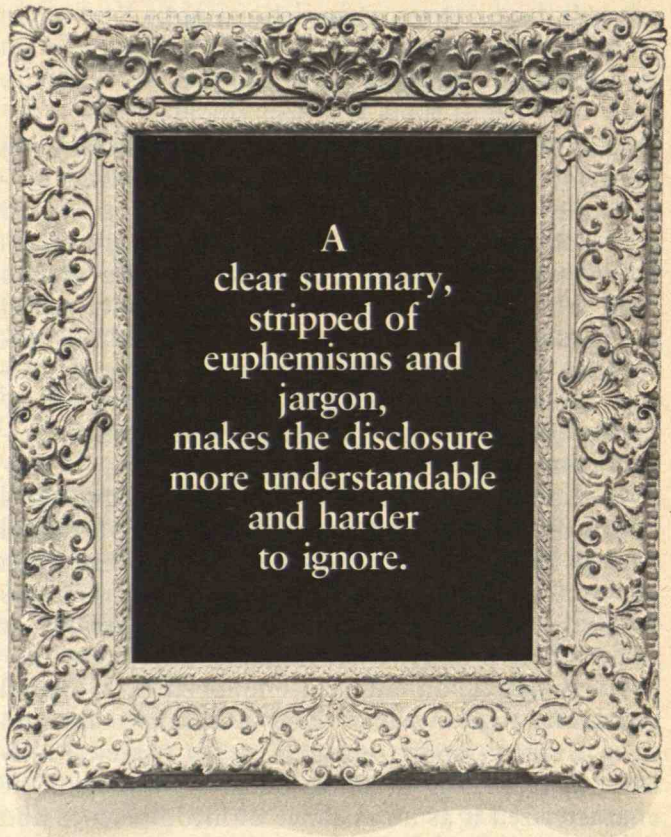
Going Public

When a disclosure within channels has failed, the next step is going public. As with every facet of whistleblowing, this requires great care.

The need for a simple and convincing summary cannot be overemphasized since the training, experience, and attention span of public recipients of the disclosure is usually less than that of the employer. The summary should attract the reader's attention without sensationalizing or distorting the information. The line between illuminating and distorting the facts is a difficult one to draw, but there are certain guidelines. A whistleblower should not make the disclosure on company letterhead, or in a manner calculated or likely to make the disclosure seem official. The whistleblower acts on his own in going public and must take pains to stress this fact. He should therefore not make a public disclosure on company time or with company resources.

The whistleblower should never make an anonymous disclosure unless there is no choice. Anonymous disclosures lack credibility and place a heavy burden on the recipient, who may lack the resources and capability to confirm the information. Anonymity also precludes, or complicates, follow-up communications. Moreover, it furnishes a ready-made diversionary tactic for the employer, who may charge that the whistleblower lacks the courage and conviction to stand by his disclosure. Finally, anonymity is usually short-lived. Management can often identify the whistleblower from the disclosure, particularly if it involves complex technical information. Or management may confront "suspects" directly, precipitating a confession or a lie.

"To whom should the public disclosure be made?" is perhaps the most difficult question. The safest and frequently most appropriate entity is a civil authority, particularly a regulatory agency.



Disclosures to many federal regulatory authorities are now protected by statutes that prohibit retaliatory actions against employees who report possible regulatory violations. In addition, the Civil Service Reform Act of 1978 protects federal employees who make disclosures of waste, fraud, or substantial health or safety hazards to the Merit Systems Protection Board or agency inspector general. Also, disclosure to civil authorities may be the most effective since they usually have the duty and resources to follow up.

When a regulatory agency fails to act, it may be appropriate to make the disclosure to Congress or a state legislature. Federal statutes protect disclosures to Congress in certain circumstances, and legislators to whom the disclosure is made may use political pressure to protect the discloser. However, neither Congress nor most state legislatures have any meaningful legal sanctions to bring to bear; they are poorly equipped to follow up, particularly if the disclosure is technical; and their view of the public interest is obviously tempered by political considerations. The record of congressional committees in protecting those who testify before them is poor, and their attention to disclosures tends to be spotty and superficial.

A more promising source of follow-up and sustained support may be a public interest group specializing in the disclosure subject. Such groups often have the expertise to appreciate the information, the knowledge to use it, and the public relations sense to maximize its exposure. The danger in making the disclosure to such a group is that the whistleblower may involuntarily find herself identified with a shrill position. Several whistleblowing engineers from the NRC, for example, worked with a private group that was critical of nuclear power. They were instantly labeled "antinuclear," although they were all in favor of nuclear power.

Disclosures directly to the media should be considered only a last resort. If it comes to that, the whistleblower should remember that his job is not to write or even sell the story — he is simply making it available to the journalist — and he should not vary the format to make the information more newsworthy or "colorful." In fact, many journalists are rightfully suspicious of stories that are pressed on them as sure headline-getters. A good journalist recognizes newsworthy information and is more likely to consider it credible if it is presented in a low-key, factual manner.

In addition, the whistleblower cannot count on confidentiality. Although it is probably an overstatement to say that one is never "off the record," a journalist may be unable to keep a good-faith promise of confidentiality. Led by the Supreme Court, the courts have grown increasingly hostile to claims of "reporter's privilege," and the whistleblower who discloses information to the media "confidentially" has no guarantee that the journalist will not subsequently be forced to reveal it.

Finally, whistleblowers who go to the media should not expect prolonged follow-up. Journalists (and their readers) have notoriously short attention spans, and their staying power is subject to their editors' continual pressure for new stories. There are few disclosures that warrant more than one or two stories; detailed follow-up analysis and confirmation will not often be forthcoming.

Anticipate and Document Retaliation

Since whistleblowing calls attention to information that someone has disregarded — or worse, suppressed or falsified — it inevitably causes tensions and embarrassment and often triggers a defensive reaction from an employer.

The classic response to a whistleblowing employee — the *ad hominem* defense — is to divert attention from the disclosure to the discloser by attacking her motivation. This tactic transforms the problem into a mere "personality conflict," which is comparatively easier for management to deal with. In fact, after a study of a large number of government whistleblowers, one congressional report concluded that regardless of the nature or validity of the issue involved in the original allegation, the major response of the bureaucracy is directed to the employee who came forward and not to the problem. Once attention is centered on the employee, the bu-

reaucracy knows how to deal with the problem.

In one prominent case, the whistleblower was accused of not being a "team player." In another, the employee was described as antagonistic to his supervisors, and his involuntary transfer was attributed to unspecified "difficulties that have existed between you and your supervisor." In a third case, the managers, embarrassed by the disclosure, attempted a one-sided interview with the whistleblower in a search for information to use against her. When she declined to answer all their questions, she was dismissed for poor work quality and failure to cooperate. "Insubordination" is another frequent charge, often resulting directly from management's efforts to prevent the disclosure. Such retaliatory acts range from mere bad-mouthing or harassment to demotion, surveillance, or dismissal.

Challenging Retaliation

For federal employees, the right to blow the whistle is now protected in several ways. The Civil Service Reform Act of 1978 specifically provides protection against reprisal for the lawful disclosure of information that a federal employee believes shows "a violation of any law, rule, or regulation, mismanagement, a gross waste of funds, an abuse of authority, or a substantial and specific danger to public health and safety." The First Amendment of the Constitution, of course, affords protection, as do federal statutes guaranteeing employees the right to petition Congress. Moreover, some individual agencies have their own regulations that provide additional protection.

While some of these measures are in their infancy, the courts have long applied First Amendment protection to government employees, and have evolved a rule that actions against an employee motivated in substantial part by the exercise of First Amendment rights are unlawful unless the employer can show, by a preponderance of the evidence, that the same decision would have been reached despite the First Amendment activity. The employee, of course, has the benefit of the Freedom of Information Act and the Privacy Act to obtain information about any personnel action.

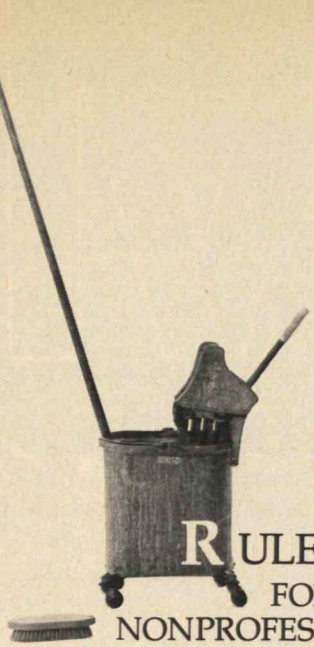
In contrast, the rights of a private-sector whistleblower are more problematic. As noted above, if she blows the whistle to a regulatory agency, she may be protected by federal statutes. If she is a member of a union, she may also be protected to the extent that a retaliatory dismissal is subject to arbitration.

But without these protections, the private-sector whistleblower is largely at the mercy of geography. Courts in most states still adhere to the doctrine of "employment at will," which provides that an employee can be fired for any reason, or for no reason at all, unless an employment contract states otherwise. In these states, the fired whistleblower has no recourse unless he can convince a court that the law should be changed. Some plaintiffs have done just that in several state courts, arguing either that their employment relationship involved an implied duty of good faith by the employer, or that the dismissal should be declared unlawful because it was contrary to public policy. Because the law is changing rapidly in this area and varies dramatically from state to state, the whistleblower may want to consult a lawyer or the American Civil Liberties Union. Although the decision to blow the whistle will presumably be made on ethical and moral grounds, the manner in which it is blown may be affected by the specific law of the state.

Proof of Retaliation

A legal right to blow the whistle is not self-enforcing — the whistleblower has to prove his case. He must convince the fact finder that the retaliation was motivated in whole or in part by the disclosure, and refute the argument that the action would have taken place even if the disclosure had not. Only by accumulating documentary evidence and independent witnesses can a whistleblower hope to avoid a swearing contest if the case ends up in court.

The problem here is that the whistleblower rarely has the legal training to understand problems of proof and the nature of legal evidence. The scientist, for example, may understandably confuse proof in her field of science with legal proof — although the



RULES FOR NONPROFESSIONALS: THE SAME, ONLY MORE SO

The thin volume of literature on whistleblowing is peculiarly snobby; it is written as if the whistleblower is inevitably a professional or a well-educated, specially qualified white-collar worker. But what about the janitor or secretary who learns of information he or she feels morally compelled to disclose?

The rules here are not much different from those for professionals, but they are a great deal harder to follow.

First, the nonprofessional often lacks the training or expertise to assess technical information and establish credibility. Nor does the nonprofessional have qualified colleagues to turn to.

Second, the nonprofessional cannot invoke the ethical standards of a profession to justify a disclosure. Scientific professionals are regarded as owing "special obligations" to society that temper — and sometimes supercede — their narrower duty of loyalty to employers.

Perhaps as a result of these factors, there are few reported cases of whistleblowing by nonprofessionals. But the judicial attitude toward nonprofessional whistleblowers is illustrated by the case of a secretary who refused to work in an office where employees were instructed to tape telephone conversations without telling the caller. A Pennsylvania court agreed that her refusal was "the path of prudence" since such taping was a criminal misdemeanor. What makes the case noteworthy is that the court did not go further to state that she had a *right* to take action and to reinstatement in her job.

Fortunately, the nonprofessional who reports health, safety, or environmental hazards to federal regulatory authorities, or cooperates with them, is protected by the federal employee protection statutes, which apply to "any employee" without regard to professional status. But until state laws catch up with federal legislation, the nonprofessional who blows the whistle — to someone other than a federal regulatory agency — may not even get a pat on the back for "prudence," much less keep his job. — *P.R.-H.* □

two are totally distinct. While the detailed problems of proof should be left to someone trained in the law, the would-be whistleblower should at least understand the definitions of hearsay, opinion, and surreptitiously obtained evidence.

Hearsay is something heard from another. Since it is secondhand, it is not as other reliable as evidence and may be given less weight or even totally excluded by a court. Although there are exceptions to this rule, the whistleblower should not expect simply to recite what others have told her, no matter how damaging it may be; she needs others to testify themselves. Time and again, professionals without legal training fail to understand this rule, and what they thought was a powerful and convincing case is reduced to the weakest circumstantial evidence or thrown out of court altogether.

Opinion testimony is limited to that which is based on the witness's perception or personal knowledge and which is helpful to a clear understanding of his testimony or determination of the fact at issue. "Opinion" concerning someone else's state of mind is practically never admitted. Unless the witness can read minds, he does not know what others are thinking or what motivates them, and he is not permitted to speculate.

Surreptitious evidence — a term used here to refer to evidence obtained by tape-recording, eavesdropping, "leaks" from friendly employees ("closet patriots," in one government whistleblower's phrase), or from a restricted source — may not be admissible evidence in court. For example, without a warrant, it is illegal to tape a phone conversation without the consent of either party; evidence produced from illegal wiretaps is usually inadmissible. Nevertheless, some whistleblowers have blithely intercepted telephone conversations and offered the evidence to an attorney. And even if surreptitious evidence was legally obtained — such as a telephone conversation recorded with the consent of one party — the way in which the evidence was acquired could offend a fact finder and bring no credit to the whistleblower, whose motivations and character are probably already under attack. If a whistleblower has to depend heavily upon this type of evidence, he should

think hard about whether the fight is worth the cost in terms of personal integrity and self-esteem.

The fired whistleblower who goes to court must know the difference between proving that he was right to blow the whistle and proving that he was fired in reprisal. In a legal challenge to retaliatory action, the issue is not whether the original disclosure was correct (appropriate or "good" in some ultimate moral sense), but whether the challenged action was motivated in whole or substantial part by the disclosure. Moreover, evidence of the correctness, propriety, or truth of the disclosure may be excluded altogether on grounds of irrelevancy. Courts and other fact finders try to resolve only what they *must* resolve, and the whistleblower who wants to use the courtroom as a forum for ventilating the entire issue may be sorely disappointed.

When to Give Up

This bleak array of "dos and don'ts" suggests that whistleblowing is lonely, unrewarded, and fraught with peril. It entails a substantial risk of retaliation which is difficult and expensive to challenge. Furthermore, "success" may mean no more than reinstatement to a job where the bridges are already burned, or monetary compensation that cannot undo damage to a reputation, career, and personal relationships.

This being the result of "successful" challenges, the best recommendation is often: give up and move on. What should be given up, of course, is not necessarily the whistleblowing itself; whether to blow the whistle is a moral and ethical question that should not turn on mere personal interests. What should be given up is "the case" — the challenge to retaliatory action. Too often, "the case" becomes the sole object of the whistleblower's life; and, even after repeatedly losing legal battles, the individual sees new evidence of retaliation in every word breathed by her former employer. Here it is best to write off the lost time and begin over.

The best and shortest advice on how to blow the whistle has probably been given by one of the first whistleblowers. He says that if he had to do it all over again, he would do two things at the outset: line up a good lawyer, and line up a good job! The would-be whistleblower who cannot do both should plan for trouble and blow the whistle defensively. □

Further Reading

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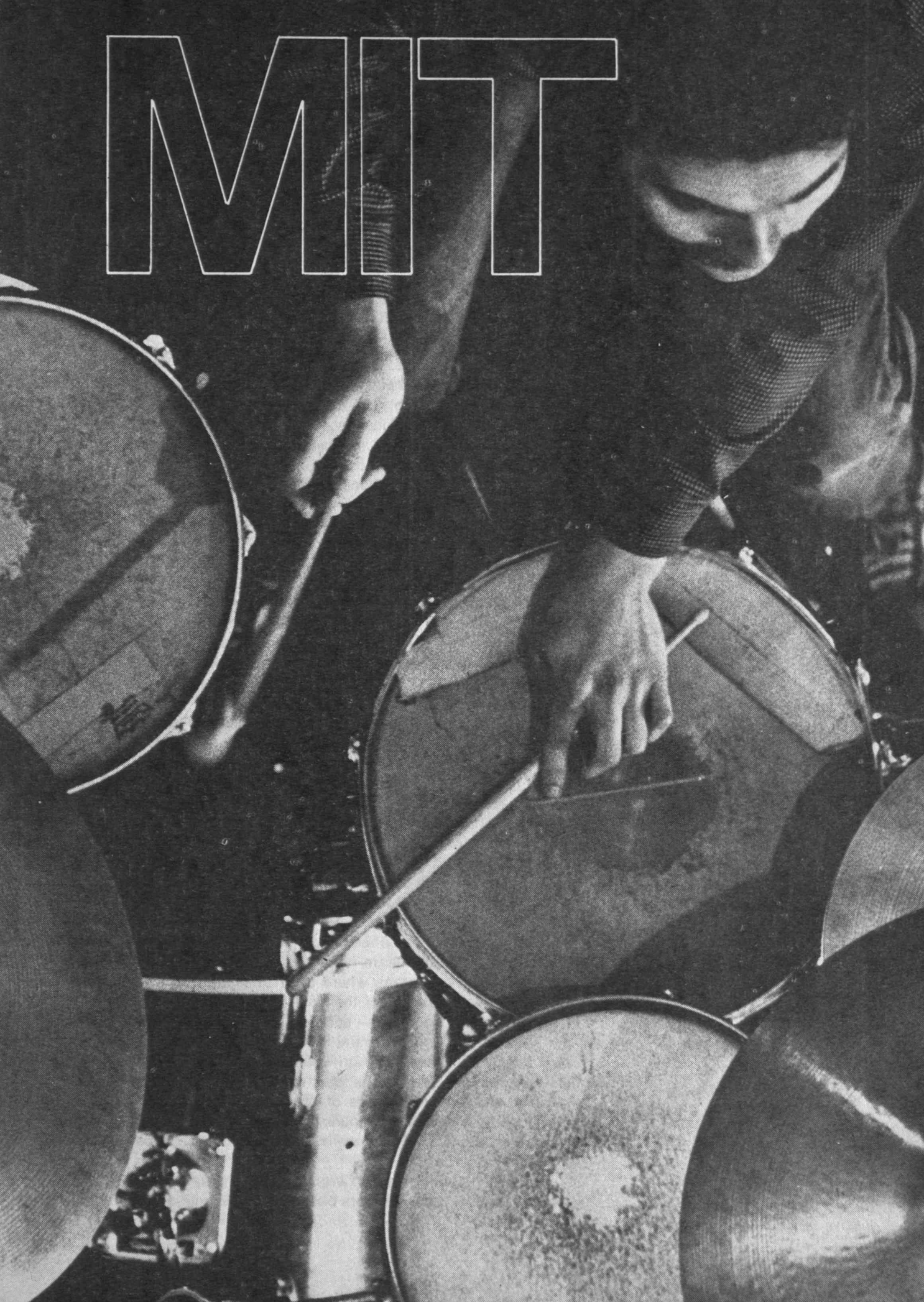
Peter Raven-Hansen, an attorney in private practice in Washington, D.C., has represented several whistleblowers in conjunction with the American Civil Liberties Union. He is a member of the American Association for the Advancement of Science (AAAS) Committee on Scientific Freedom and Responsibility, and of the executive council of the Federation of American Scientists.

This article is based on a longer paper delivered at the 1980 annual meeting of the AAAS, which will be included in *Scientists as Whistleblowers: Eight Years of Experience Since the BART Engineers*, to be published by AAAS/Westview.

MIT



M.I.T.'s Report Card: Accreditation Team Sees Clear Sense, Strong Spirit

"The best education results from close contact with up-to-date real-world scientific and engineering problems."

M.I.T.'s accreditation within the New England Association Schools and Colleges was never in doubt. But the review of the Institute's undergraduate teaching in its nonprofessional aspects by the Association's evaluation team was embraced as a once-in-a-decade opportunity to be judged by uniquely knowledgeable, independent critics.

Almost without exception, the visitors liked what they saw. The team of ten distinguished professionals and educators who visited the campus just a year ago was headed by H. Guyford Stever, chairman of the Assembly of Engineering of the National Research Council, who was a member of the M.I.T. faculty for nearly two decades ending in 1965. Walter H. Stockmayer, '35, Smith Professor of Chemistry at Dartmouth, was among its members.

The Institute's goals in this nonprofessional arena are widely understood and shared by all constituencies — students, faculty, administration, and Corporation — said the team's report released late last winter. M.I.T. "exudes a very clear sense of purpose and direction," and the faculty has a strong *espirit de corps*.

"There is a very strong innovative thrust to all that M.I.T. does," said the report. "As a preeminent institution in science and technology, M.I.T. believes that . . . it should constantly be seeking the cutting edge of each of the fields in which it conducts research and education.

"There is a clear belief . . . that the best education results from close contact with up-to-date, real-world scientific and engineering problems. There is a sense of confidence and power given to all of the community that they are involved on a broad frontier. They feel proud to examine the problems of science and technology not only from the disciplinary points of view, but also from the point of view of a concerned society, to make sure that advances fit the needs and wishes of society."

Though there are a few long-term problems — some of which are related directly to attempts to reach some of the more elusive and demanding goals — the evaluation team reported that M.I.T. "has served society very well indeed in those areas where clear attainment of its goals has been achieved." Without exception, the Institute has identified its problems, and — though some are "serious" — none is "unmanageable," said the report.

The evaluators concentrated on four issues which M.I.T. has singled out in advance for their attention — and one problem which the team members selected themselves. The latter was finances, on which they were substantially reassured. Members of the Corporation and administration acknowledged the difficulty of financing "such an expensive educational and research program." But they were "confident that it can be handled in the future" as in the past.

On the four problems on which M.I.T. had prepared self-studies for the panel's attention, the evaluators basically agreed with the Institute's view of itself. The four:

Page A1: Building 7 lobby entertainment (Photo: James J. Snyder, '80)

☐ The pervasive sense of competitive pressure and tension among students and — to a lesser extent — faculty. On the basis of its anecdotal evidence from selected students, the team concluded that too many students are "grinds;" they overload themselves with courses and miss too many of the important benefits of an M.I.T. education. Students themselves, said the team, described M.I.T. as a "pressured" environment, and they didn't like it. The panel spoke of students' "monastic" lives and the view held by many students, said by their colleagues to stem from "an absence of academic freedom," that M.I.T. "is out to screw them."

☐ The inadequate use and availability of computers in the basic educational process. The panel agreed that "the computer environment at M.I.T. is very rich indeed" — at least 200 computers, including some very large ones and a number of smaller, special-purpose machines. But they identified with the issues raised more than a year ago by an *ad hoc* Committee on Future Computational Needs and Resources (*see page A10*); M.I.T. should do better, they said, "in the educational use of computers."

☐ The humanities, "the most controversial and eternally puzzling component of the M.I.T. educational enterprise." The accreditation team found that many students — and at least some members of the faculty — see the humanities as "marginal, dilettante activities." These attitudes are transmitted to the humanities faculty and to prospective students, with the result that the faculty tends to be defensive and demoralized and prospective students who would be strong in both sciences and humanities may be discouraged from coming. The panel concluded that most undergraduates feel they receive too little exposure to the societal impact of the science and technology they study. The proposed College of Science, Technology, and Society is aimed exactly at this target; but it "has a long way to go before it will have achieved its potential," concluded the panel.

☐ The place of women and minorities. Though faculty women praised the Institute's affirmative action program and those who administer it, they said they share a problem common in technical disciplines: male colleagues treat them as "not quite serious" no matter what their professional accomplishments. Women students made similar complaints, and the panel concluded that M.I.T. "needs more women on all levels in all capacities . . . the only way to solve many pressing problems." Minority students interviewed by the panel presented "a litany of complaints . . . a mixture of elitism and racism . . . that saps" their self-confidence. The team was sympathetic but guessed that the problem is "what we would expect to find at any institution characterized by high status and high pressure." Its recommendation: "continued efforts to enlarge the proportion of minority students." — *J.M.*

Would You Do It All Over Again?

Thirty years after he became president of M.I.T., James R. Killian, Jr., '26, gave up his last official assignment at the Institute when he retired from the position of honorary chairman of the Corporation last June 30. To punctuate that event, and to commemorate in a modest way the contributions of those 30 years, the Review *asked Dr. Killian to talk about some highlights of his service to M.I.T. with Frederick G. Fassett, Jr. Mr. Fassett succeeded Dr. Killian as editor of* Technology Review *in 1939, and he continued almost without interruption to serve M.I.T. until his own retirement (as dean of residence) in 1966.*

When the two met last fall under the Review*'s aegis for the conversation whose highlights are recorded below, it was a warm, even emotional, reunion of two old friends both of whom are admired literally by thousands in the greater Institute community worldwide.*

F.G.F.: As I was sitting in the Stratton Building waiting for the clock to go around this morning, looking out to the Chapel and McCormick Hall and the greensward, I couldn't help being impressed by the students on their way to class. First there were boys and girls, and then along came a whole cluster of young marrieds with little ones by the hand.

Now when I first came here there was nothing of that sort in the environment at all. It was an all-male world; but once in a while some little child would show up, and these great hirsute hellraisers would melt because here was a little one like the kid brother at home.

We now have a living, vital community of a kind that didn't exist 40 years ago through the married village and the young wives and the youngsters and the many co-eds. I think that that has been of inestimable, beautiful value to us, one of the most important changes at M.I.T. since the war.

J.R.K.: That change began during the period immediately following World War II when we had the job of reconversion here at M.I.T.— of pulling out of a massive war effort and changing back to an academic environment. It was one of the most exciting experiences in my career here.

When the Institute announced that it would re-admit all the M.I.T. students that had been registered here and had gone to war, we discovered that many of them would come back with wives, and we realized we faced a requirement for housing married students. That was when we decided to build Westgate — a village of temporary little houses, some with their own gardens, at the west end of the campus. The village proved to be a really attractive and memorable environment for the students who lived there.

And then in 1960 we began to think hard about the admission of women to the Institute. Despite a study of the performance of co-eds at M.I.T. that took a very negative view, Jay Stratton and I decided that we would do what we could to encourage more women to come and to encourage the Admissions Office to admit them. That's when the numbers of women started to grow slowly. (This was, of course, before "affirmative action"!)

Margaret Compton and some wives of faculty members sponsored a women's residence on Bay State Road and spent a lot of time advising and helping and encouraging women students, and Mrs. Stanley McCormick, a remarkable woman who had been a co-ed here herself, took an active interest in M.I.T. women.

Mrs. McCormick spent part of each year in Santa Barbara, and around 1950 I visited her as a part of our capital fund-raising compaign. She said she wanted to help the Institute but that most of her help would probably be coming in the future. So President Julius A. Stratton and I continued to keep in touch with her, especially when she was in residence at her Boston house on Commonwealth Ave., and in the 1960s she became increasingly interested in the women students and reached a decision to do something significant. That, as you know, was the contribution to make possible McCormick Hall. Mrs. McCormick took a great interest in the design of the building and in furnishing it, and this elegant dormitory proved to be the turning point in increasing the numbers of women at M.I.T. — because suddenly we had superb acccommodations for them.

I'll always remember that wonderful lady. A Boston debutante, she decided to seek entrance to M.I.T. to study biology because she wanted to do laboratory work and she could not at that time find any womens' college that had laboratory facilities in biology. The first time she applied for admission to M.I.T. she was refused admission as a regular student because she couldn't meet the mathematics and science entrance requirements. So she studied for three years to prepare for the Institute, gained admission, and spent four years obtaining a degree in biology. Thereafter she never lost her interest in biology, was deeply involved in the whole population control movement, and supported birth control research.

One day in the late 1960s I had a call from her secretary, who said that Mrs. McCormick would like to see me to talk about the disposition of her house on Commonwealth Avenue. Did M.I.T. have any interest in it? So I went over and when I got there her secretary said that there would be a delay, that Mrs. McCormick had decided that it was not proper to meet an administrative officer of the Institute in her bedroom — she had been confined by illness — so she was dressing to come down to the reception room to greet me. And when she did come down she did so with great dignity, wearing a hat and coat and gloves, and we sat and talked for about an hour. It was one of the most moving experiences I've ever had. We talked about

her plans for the Institute and her interest in its work and especially in the women who attended.

Within a month after that she was dead, and we soon were informed that Mrs. McCormick's will provided a large legacy to the Institute.

F.G.F.: Mrs. McCormick's kind of devotion is the kind that makes things go.

J.R.K.: You, too, Fred — and Julie — made a superb contribution when you were dean of residence, to the intellectual and emotional climate of our students.

F.G.F.: That was one of the most pleasant experiences I ever had. The group of people who were housemasters and tutors and all that. It was a superb experience.

J.R.K.: I just found in the files a public statement that I made on one little incident that you may or may not recall.

F.G.F.: I think I do.

J.R.K.: There was something happening on the West Campus, and the police arrived and arrested you, alleging that you were inciting students to demonstrate riotously off campus. They were prepared to throw the book, and I issued a public statement saying that this was surely a case of mistaken identity and reaffirming your responsible character; and the charges were dropped.

F.G.F.: Oh, yes, that was a wild night, my gracious.

Cultivating Students' Latent Abilities

J.R.K.: Another of the important contributors to this community in the late 1950s was Edwin Land. I became aware that Dr. Land was deeply interested in education and concerned about what he felt to be the failure of the universities to develop the creative potential of their students. So I initiated an appointment for Dr. Land as a visiting Institute professor, and he was then invited to give an Arthur D. Little Lecture that proved to be an enormously influential educational policy statement here at M.I.T.

In that lecture he proposed that students be involved in research even as freshmen, and that faculty members work with these students, one to one, to give them stimulation and help as co-workers and research partners. He felt that out of this would come a whole new stimulus to the development of latent creative abilities of these students, and that colleges were failing to accomplish this. Dr. Land donated funds for the development of experimental courses, and after a period of four or five years his stimulus led to the establishment at M.I.T. of what is called the Undergraduate Research Opportunitues Program (UROP), which I think it's not extravagant to say was the most important advance in undergraduate education at M.I.T. in the 1960s and 1970s. With imaginative faculty leadership, UROP has become enormously successful, an innovation of the first order.

Toward Humaneness and Liberality

There have been other heartening developments at M.I.T., too. One is the growing preoccupation with the humanities which William Barton Rogers stood for and advocated and planned for. In his autobiography, *Trolley to the Moon*, the late Eric Hodgins, '22, wrote of the miracle of the Humanities Department at the Institute when he was a student, of his friendship and relationship with Professor Tubby Rogers and others, and of the extraordinary faculty that together created what was in effect a superb liberal arts college within M.I.T. In the same way, when I was a student I found that department and the courses I took in it were very influential in my development. You, Fred, became a teacher later in that superb group, and your contributions to the humanities and later as the editor of *Technology Review* were among the achievements to which I attach great significance and importance.

Now under President Wiesner's leadership we are moving toward a program devoted to science, technology and society, to explore how we can encourage liberal arts studies appropriate for our technological society. The program recognizes that we have a technological society and that we must prepare people to act with humaneness and liberality in running it and in coping with its problems.

Another thing that's been happening is the growing preoccupation, really starting with students, with those fields of professional activity that are devoted to human welfare. For example, there has been a steady increase over the last several decades in the number of students electing to study medicine. Now some 12 percent of our bachelor's graduates are going on to medical school — and being admitted and being welcomed — because they see a medical career as a way to serve society more humanely than some other professions.

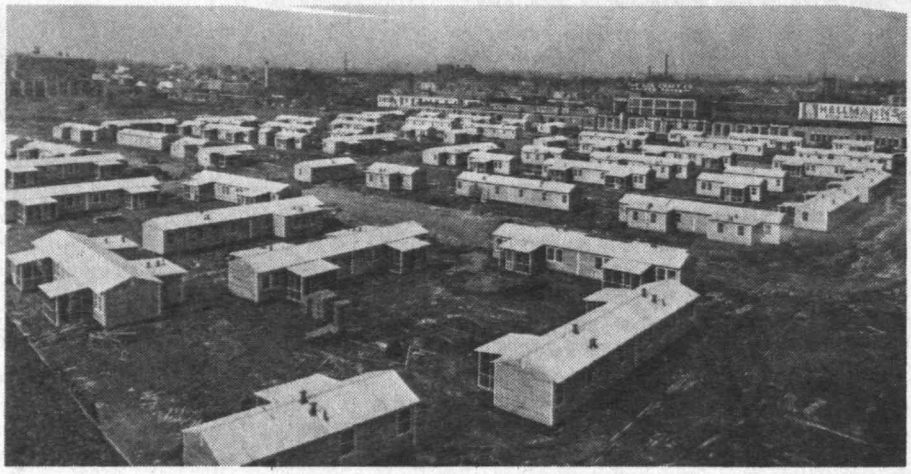
In addition, there has been the parallel development under Presidents Stratton and Wiesner of programs in the health sciences here at the Institute; at the present time something like a third of all our academic research is in the life sciences.

That work grew so successfully that around 1969, the head of the National Insti-

Professor "Tubby" Rogers, above, *was everyone's favorite.*

*Among events of "the old days" recalled by James R. Killian, Jr., '26 (*top left, opposite*), for Frederick G. Fassett, Jr. (*center, opposite*): "I'll always remember that wonderful lady," says Dr. Killian of Mrs. Katherine Dexter McCormick, '04.* Above, *the living room in which Dr. Killian last saw her;* below, left, *she speaks at the dedication of "her" dormitory. (Photos: M.I.T. Historical Collections)*

The first association of Fred Fassett and Jim Killian was at Technology Review, *whose principal talent was captured in the photograph,* left, *in 1942: the late Harold E. Lobdell, '17 (*left*), publisher; Dr. Killian; the late Henry B. Kane, '24; and Mr. Fassett. The early photograph* (below) *seems to belie Dr. Killian's recollection of Westgate: "a really attractive and memorable environment," he recalls, for the flood of married students who came to M.I.T. at the end of World War II.*
Opposite: *most readers of the* Review *will remember Fred Fassett as dean of residence – "a superb contribution to the intellectual and emotional climate of our students," Dr. Killian says. (Photos: M.I.T. Historical Collections)*



tutes of Health came to M.I.T. with a representative of the Commonwealth Fund to propose that we establish a medical school; they said they were convinced of the need in this country for a medical school that had a technological orientation, and they offered to raise $50 million or more if we would undertake to do this. This occurred just as Howard Johnson was taking office as president, and at his direction there was intensive study of the proposal. We finally came to the conclusion that our best contribution would not be to undertake a medical school with all of its complexities and financial requirements. It would have taken $150 million to establish a first-rate medical school then — and large funding to keep it going.

Instead, we said we would undertake in our own way to make major contributions to the health sciences and health care. At the same time, Dr. Wiesner, who was then provost, discovered that the Harvard Medical School under Dean Robert H. Ebert was struggling with the question of whether it should set up a division of engineering in order to bring bioengineering into its teaching and research. Clearly, there was a somewhat miraculous opportunity for joint action, and a decision was duly reached to undertake a joint program in which the technology would be handled at M.I.T. and the clinical work at Harvard Medical School. So was established the Harvard-M.I.T. Program in Health Sciences and Technology. Since then there's been developed a whole new subculture, with doctors recognizing that engineers have a major contribution to make and engineers respecting the M.D.s and understanding their points of view.

These are some of the things that have been happening at M.I.T. to give it a new relationship, I think, to the needs and opportunities of our time. They reflect that phrase that I used in my inaugural address, "a university polarized around science."

F.G.F.: That is a wonderful phrase, and it is just as good now as it was then.

As you look back over the 30 years since that inaugural day, would you do it all over again?

J.R.K.: I think so.

F.G.F.: Are you sure?

J.R.K.: Yes. There were times that were hard, vexing, and discouraging; but they were minor in comparison to the sense of obligation and opportunity.

One of the grievous times was the period dominated by the reactionary outbursts of Senator Joseph R. McCarthy. Eight days after I was inaugurated as president, the papers were headlining the testimony of a man named Philbrick at a Communist trial in New York who said that an M.I.T. professor named Dirk J. Struik had been involved in teaching communism in a school in Boston. And suddenly we were pushed into a period of very tough defense of the academic freedom of universities and demonstration of our loyalty to democratic ideals.

We refused to break Professor Struik's tenure when he was indicted by the state, saying that if he was guilty it was up to the established judicial system to determine that, and not up to us, for we had no competence to do it.

I remember one incident that will suggest the kind of pressure we were under during this period of McCarthyism. At the height of his influence Senator McCarthy became interested in work that people in the Research Laboratory of Electronics were doing at the request of the Voice of America; for some spurious reason, he decided that there was something wrong about this, and he made public charges that communist interests were being served by what Institute personnel were doing to advise on the location of a radio transmitter for Voice of America broadcasts. One day a couple of his staff arrived at my office, saying that they had come to examine our personnel files. While giving them public information about several staff members, I told them that we did not permit examinations of our personnel files. They pulled out a batch of subpoenas from their pockets, signed by McCarthy but in blank, without any names on them, and said they would be back tomorrow with names on these forms, and they would execute their subpoenas unless we gave them access to our personnel files. The next day, when we told them we would not admit them to an inspection of our personnel files, they got up and left — and nothing ever happened.

The attacks on the Institute ended only when the Supreme Court, in relation to a wholly different problem, reached a decision that undercut the indictment that the state of Massachusetts had brought against Professor Struik. I'm proud that the Institute was strong enough to stand firm in protecting its freedom and integrity, and I think the way we did that helped other institutions resist some of the pressures that were on us all.

Another grievous period was 1969 when the student protest peaked and we had severe problems here at the Institute. For a period there was a genuine worry that this movement of attack and protest could destroy the institution, and under President Johnson's firm and skilled leadership there was a great gathering of forces within the Institute of courageous and brave people who resisted that, and I think in the end we came out stronger as a result of it.

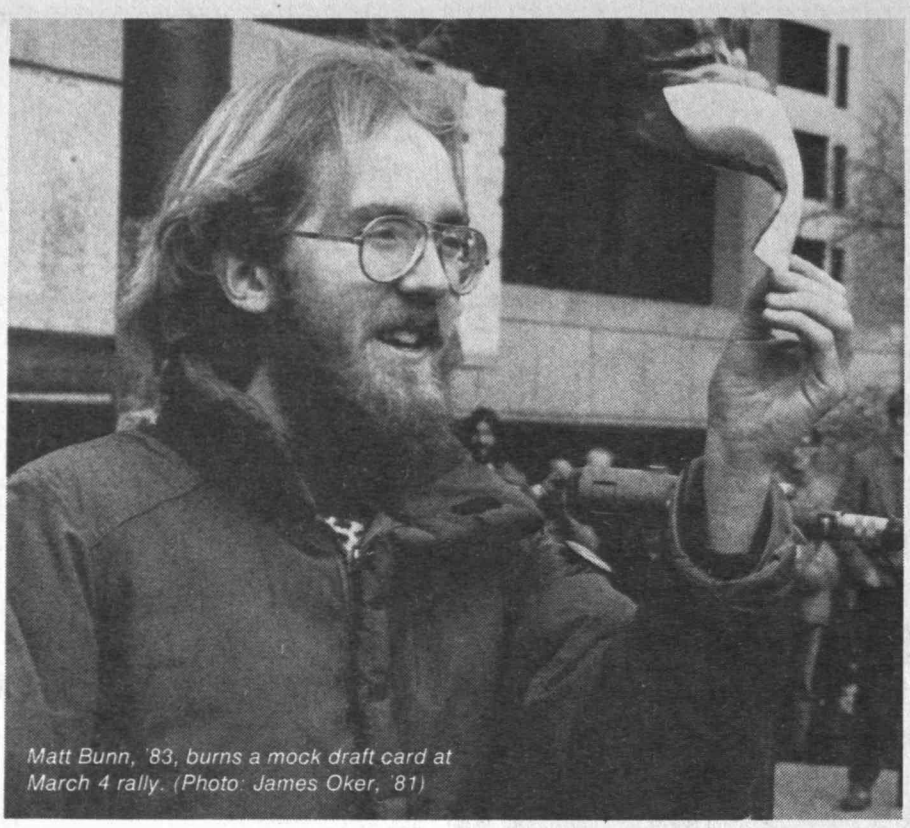
These are the things you remember and can be proud of. Of course there were times during my presidency, particularly during the McCarthy period, when I must confess that I had battle fatigue.

F.G.F.: Still, even as you look back on all that once again, you would do it all over again, wouldn't you?

J.R.K.: Yes, I would. Of course I would. All of us who have ever been associated with M.I.T. love it and carry with us strengths from our experiences and our fellowship.

F.G.F.: That's very true. I remember a vivid example of the bond that holds us so strongly together — Shikao Ikehara, when he came back from Japan for his 50th Reunion. I had come to know him through Vannevar Bush long back, and we were pretty good friends. We hadn't seen each other in a decade, but we agreed to meet in the Julie Fassett garden on the morning of his Reunion. We did, and we sat there a bit in the rain, but the rain didn't matter. Dr. Ikehara told me of his respect and affection for M.I.T., and of what he had been doing in Japan to help the Institute's interests, and of how he treasured the opportunity to return.

It was, you know, one of those rare, nice moments — the kind that means M.I.T. has been such a special place for all of us.



Matt Bunn, '83, burns a mock draft card at March 4 rally. (Photo: James Oker, '81)

Echoes of 1969: New Movement to Peace, Love, and Humanity

by Steven J. Marcus

"March 4th isn't a day; it's a movement." That's what we said in 1969 as we gathered at M.I.T. and at campuses elsewhere across the nation. We listened, discussed, debated, exhorted: on the misuses of science and technology; the complicity (intended, or by default) of its practitioners; the spectre of Vietnams without end; the seemingly inexorable drift toward nuclear Armageddon. And most important, we proposed strategies — however dim and embryonic — for changing such policies and their misbegotten technologies into forces for peace, health and usefulness.

Although our "movement" was not quite as long-lived as we'd hoped, most activists of the era — no matter how "straight" and conventional they may now have become — still believe their experiences of the '60s, in the jargon of the time, to have permanently "raised their consciousnesses." We are no longer out in the streets protesting — many are now on the inside, changing things, it is hoped, for the better — but we all still have a special nostalgia for the period and a longing for its return — especially in a more enlightened and ecumenical form. Like the Jews dispersed among the nations, we have kept the faith and await the Messiah.

March 4th finally returned, so to speak, to M.I.T. in 1980. And whether its organizers were inspired by messianic impulses or not, it's for sure they weren't acting to resurrect the '60s in general or March 4, 1969 in particular: "I was eleven years old at the time," said Jim Newman, '82, one of the principal student organizers of the recent event. And in the words of Susie Cohen, '82, who introduced the proceedings: "This is not a day of nostalgia for the 60s. We are here to deal with the problems we face *now*."

Current problems were classified — more for convenience than for any supposed independence — according to their global, national, and local significance: "World Perspectives" dominated the morning, "Domestic Issues" the late afternoon, and "Bringing It All Back Home: M.I.T." the evening. Speakers talked on U.S. foreign policy, the consequences of nuclear war, the internal dynamics of third-world countries, the draft, the community and M.I.T., and education as an industrial "process," just to indicate a few.

There were workshops — more informal, interactive, and problem-solving in approach than the rest of the program — that addressed these and other issues as well. "The MX Missile and Strategies for Disarmament," "Toward a Just, Sustainable, and Participatory Society," and "Racism and Sexism at M.I.T." were but three of them, exemplifying the global, national and local partitioning once again.

Is this the harbinger of a new movement — whether local, national, or global? Certainly some of the speakers hoped so. "We need to build a movement to oppose turning this country into a military concentration camp," said Salvador Luria, Institute Professor Emeritus. "No single initiative does it, but they all act as instruments of nucleation and leverage." And in straight talk not often heard in campus forums during the past decade, he added: "We are now seeing the country becoming remilitarized, supposedly because of external affairs. But it's really because of the needs of decaying American capitalism."

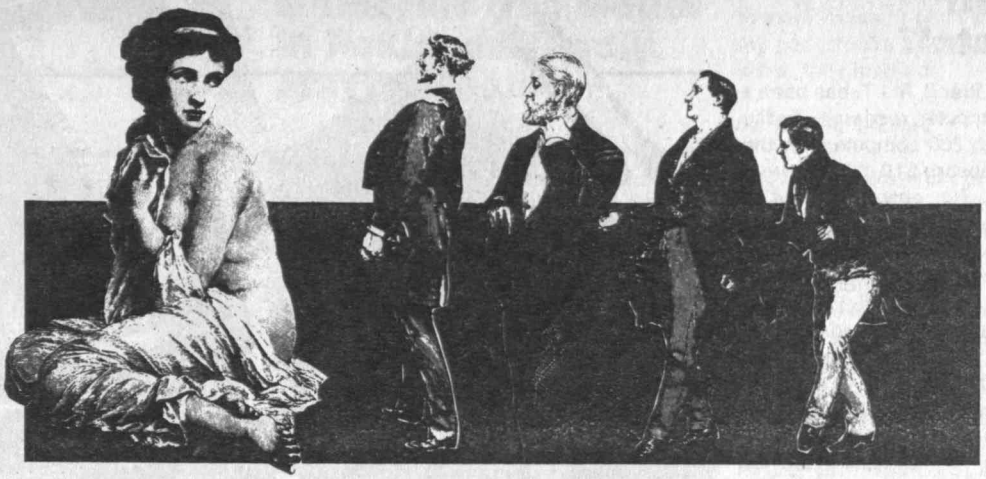
Vera Kistiakowsky, professor of physics — someone who has changed over the past eleven years "from signing the right petitions and reading the right magazines to someone who now addresses political gatherings like this" — also spoke of a "movement." "It is an excellent time now," she said, "to create a national movement." Its model, she claims, is the antinuclear movement — with the environmental, soft-energy, appropriate-technology, and interpersonal perspectives of such groups as the New England-based Clamshell Alliance.

Even among people old enough to have been active during the 1960s — and before — there was little talk of reviving old movements or even old strategies. There was no talk of "dropping out," either; it was tacitly agreed that the best way to influence affairs is from the inside and from the most powerful possible stance. Simplistic, one-issue-at-a-time approaches were rejected in favor of global views that recognize the interconnections among just about all the issues that mean anything to anyone.

A few '60s radicals were there, easily identifiable by appearance and manner (one observer quietly suggested they'd spent the last decade in a deep freeze), but the "new activism," if indeed it has arrived, will respond to the "new" militarism and the "new" cold war in a way unimagined by those attempting, a generation ago, to change the world before changing themselves.

There is a maturity and sensitivity — to issues large and small, to relationships political and personal — that is manifested in the new activism by the young and the older alike. On the controversial MX missile system, for example, which Bernard Feld, professor of physics, calls "spherically absurd" because it is just as ridiculously unnecessary no matter how one looks at it, there are more humane alternatives. With melancholy eyes, a delicate but firmly gesturing hand, and a wavering voice that seems to bear the pain and wisdom of all human history, Professor Feld reasons that "effective deterrence would be achieved by the prospect of knocking out only two or three major population centers. Even the Chinese capability to deliver small weapons to Soviet cities in Siberia is an effective deterrent." Thus, to talk of "advanced" weapons is madness. But he suggests a principle for comprehensive test ban treaties that makes military, economic, and plain old common sense — declaring moratoria on new weapons development, and on improvements to existing systems, while negotiations are in progress. In this way, each side need not run to stand still or take precipitously dangerous actions to save short-term political face.

We may one day reach the point, he adds, when the nuclear war can finally be fought. It would provide intellectual and technical challenges to all concerned, and no one would be hurt. "My simple proposal is that we fight the war by computer simulation."



Judith Richland

Sexual Harassment: New Policy for an Old Problem

Sexual harassment is as old as Father Time — and has traditionally been largely invisible in our society. But with the heightened awareness and increased frankness of modern times, the ways in which sex is used and abused in interrelations where sex should not be a factor are out of the closet.

Sexualization in the work place can range from a leer, a joke, and a subtle implication to a blatant proposition. In stereotypical form it is initiated by men in supervisory or senior professional positions, as an exercise of power over women in subordinate positions. Today it raises many other concerns as well, including the preferential treatment of one partner by the other who is supposed to be impartial.

The college campus has never been immune, and on some campuses the issue has gone public in painful and polarized ways. Not so at M.I.T., where ever since her appointment in 1973 Mary P. Rowe, special assistant to the president and chancellor for women and work, has been dealing with sexualization cases (with cooperation from many offices at M.I.T.) in an orderly fashion, avoiding the acrimony which attends public clamor.

The number of cases brought to Dr. Rowe increased in 1979-1980, and this fact prompted her to seek advice from Professor Robert I. Hulsizer as chairman of the faculty, who then named an *ad hoc* faculty-student committee on sexual harassment in June, 1979. Having finished its study, the committee concluded that the recent increase of sexualization problems is mainly in the reporting, not in the actual number of incidents.

Subverting the Policy of Equal Education

Exactly what does sexual harassment mean?

It means the obvious examples typified in the second paragraph of this report. It also means some much more common insults:

☐ A lecturer seeks to enliven his engineering slide show by flashing a nude on the screen;

☐ A professor amuses his class by remarking that cooking is the chemistry for which women are fit;

☐ A researcher pokes fun at a student who can't take the filthy language which is common in his laboratory.

Such instances are most often thoughtless, not malicious. But collectively, they "deliver the message that women students do not belong in the professional worlds to which their male professors belong, since they find those worlds uncomfortable and inconsiderate. They all subvert M.I.T.'s policy of offering equal educational opportunity to all students," says the report.

A clear definition is difficult — what one woman would dismiss as innocent or manageable flirting may elicit in another enough mental anguish to produce sleepless nights, headaches, and nausea.

Though the situation at M.I.T. is presumed not to be very different from that at other universities, "the small number of women in the professional communities to which most M.I.T. faculty members belong may make it more difficult for a woman student to cope with an incident of harassment when it occurs," says the report.

Psychological strain is particularly severe in an educational setting. "There needs to be a relationship of trust and even intimacy between student and professor. Sexual harassment can destroy even the possibility of learning," attorney Catherine A. MacKinnon, author of *Sexual Harassment of Working Women* and teacher at Yale, told *Newsweek* magazine.

Conflict of Interest

Often the story given by each involved party is contrasting. "In almost all the cases," explains Dr. Rowe, "the question is not necessarily what ensued and whether it was intitiated by one and/or invited by the other, but that there is a conflict of interest. People feel every which way about sex, but everyone agrees about the difficulties that arise when one partner has supervisory responsibility in a professional relationship." There is then, says the report, "a problem of partiality in supervision and evaluation."

From the student's point of view, propositions may seem an attempt at extortion: grades, thesis approval, or recommendations may seem to depend on sexual compliance. On the other hand the alleged harasser may agree that the events took place but have an entirely different understanding of them. Typically, says the report, the teacher had no idea the student was upset or "thought such attentions to students were commonplace and even welcomed . . .

"There is ample evidence in M.I.T. experience that employees, students, and junior faculty may feel coerced by sexual approaches from supervisors or senior faculty members," states the report.

Committee Recommendations

The committee recommends a variety of procedures:

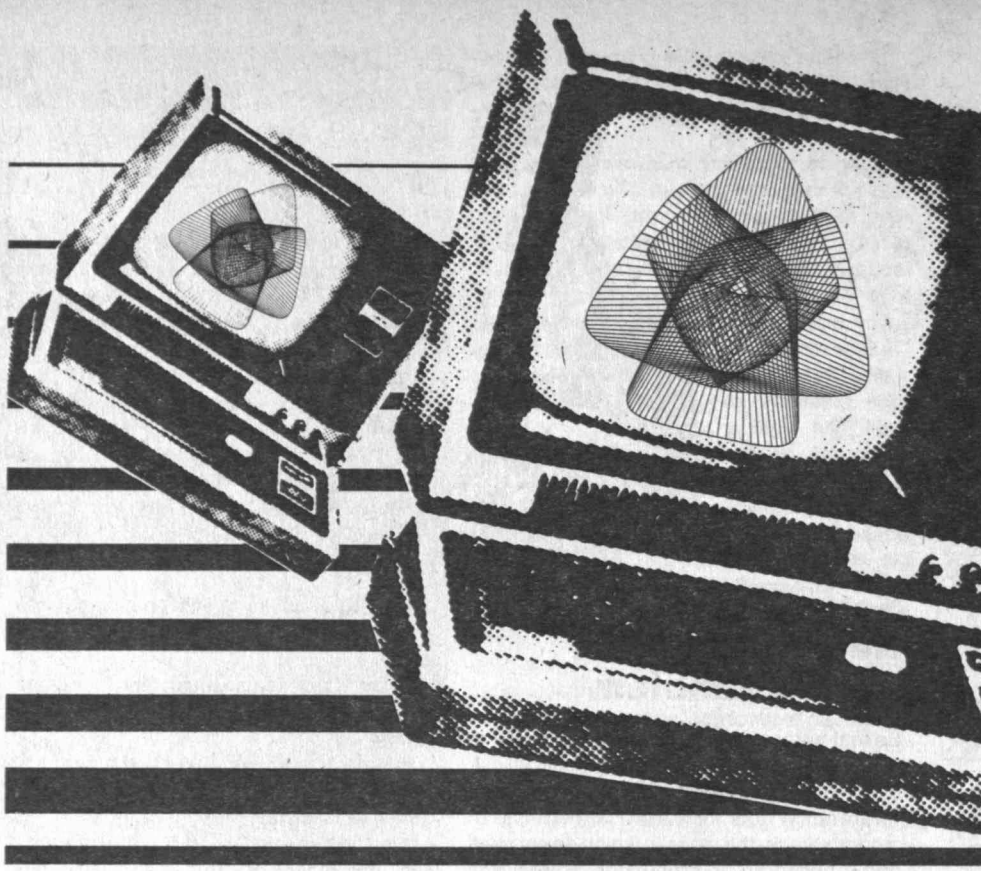
Existing policy on sexual harassment, including serious verbal abuse, should be made explicit in a written statement and circulated thoroughly throughout the M.I.T. community. The responsibility must be stressed: "To provide education, counsel, guidance, and example to students without discrimination based on sex or race." The conflict-of-interest problems must be emphasized.

The topic of sexual harassment should be discussed annually within groups such as the Academic Council and the Committee on Educational Policy for the next few years at least, "so that the effects of the publication of Institute policy can be evaluated by those groups."

A wide variety of resources are available for victims' relief and redress; the community should be informed of such resources. "More channels of communication are needed."

At a faculty meeting in February the faculty expressed its serious concern about the problem of sexual harassment and unanimously endorsed the report and recommendations of the committee.— *M.L.*

Computers at M.I.T.: Slipping off our Pedestal?



Since before World War II, M.I.T. has been a world leader in computer research. Today there are more than 200 computers on the campus, and they absorb $10 million a year in operating funds. But only 6 percent of these funds are expended on computers used in teaching, and M.I.T. is "not in a leadership position in instructional computing.

"We are not where we should be, our present path does not lead where we believe we should be headed, and — although we lead our peers in isolated cases — M.I.T.'s overall use of information processing can no longer be characterized as pioneering," an *ad hoc* committee of M.I.T. computer experts has reported to the chancellor and provost.

Though the report was written late in 1978 by a Committee on Future Computational Needs and Resources (Professor Michael L. Dertouzos, Ph.D.'64, chairman; Weston J. Burner, director of the Information Processing Services, co-chairman), it came to the faculty for general discussion only late last winter. It focusses on what Walter A. Rosenblith, provost, calls an "obstinate problem: how to integrate computers with teaching programs." Professor Rosenblith admitted that there is "no coherent view of the role that computing should and will play in the education of undergraduates" at M.I.T.; but Paul E. Gray, '54, president-designate, said the issue was among those at the top of his agenda for 1980 and 1981.

After studying computers and their management at several major U.S. universities, Professor Dertouzos and his committee concluded that the availability of interactive instructional computing to students at M.I.T. is about three times smaller than it should be. Fewer terminals are in place, and the cost of instructional interactive computing is higher than at other institutions.

(In areas other than instructional uses of computers, M.I.T. is very strong, said the committee report: M.I.T. facilities are "second to none" in many computer science research areas; it "supports a greater diversity of applications software" than any other school surveyed; and facilities for administrative computing "appear to be adequate.")

To strengthen instructional computing, the "Dertouzos committee" recommended creating an information processing and communications network for transmitting digital data among M.I.T. computers; establishing ten regional computing centers containing machines and/or terminals and staffed with experts; and adding five medium-sized computers, 400 terminals, and ten printers by 1989. Each one of these centers and terminals will represent a "port" through which members of the community can gain access to the network. The total cost (1979 dollars) might be $41 million.

The dual goal would be to increase students' (and others') access to computation while at the same time decentralizing computer resources to reduce the role of centralized control.

"We believe that it should be M.I.T.'s objective to exert a pioneering influence in the development and judicious use of information processing technology for the educational, research, and other purposes of a major university," said the committee.

Computers Unbounded in 1989

What will be the role of computers at M.I.T. by the end of the decade?
The ad hoc *Committee on Future Computational Needs and Resources* (see left) *tried to answer that question in its final report with what it called a "scenario for 1989." Here are some excerpts from that vision of the future:*

Every member of the M.I.T. community will be near to a computer port such as a personal machine or a shared terminal. Some students will own (and may even have built) their own personal machines, while others will share terminals provided at many M.I.T. sites, including dormitories and other areas of common use. Faculty, administrators, and office workers will have computer ports in their offices and often in their homes. A host of special-purpose devices will be used for classroom demonstrations, for instrumenting laboratory experiments, for speech generation, for image-processing, and other purposes.

Students of 1989 will use their ports to:

☐ Review course material, such as class notes and other information kept current by the instructing staff.

☐ Solve homework problems, through program writing and text editing, and submit them electronically to their instructors.

☐ Conduct research, e.g., simulate certain experiments that are difficult or costly by other means.

☐ Prepare theses and course-related reports with the aid of text editing and graph preparation programs.

☐ Perform bibliographical searches.

☐ Attend classes in which computers are used perhaps as basic learning tools.

☐ Communicate via the campus electronic mail and message system with fellow students, or with instructors for comments or questions on course material. The typed comment may be accompanied by a digitally-represented *mailed* voice comment to clarify or amplify the message.

☐ Communicate, perhaps via the same means, with other institutions for accessing their course materials and for other purposes.

☐ Find out what goes on at M.I.T. through the electronic equivalent of announcements and yellow pages, and participate as viewers or as active agents in some of these events.

☐ Establish or adjust their registrations, choose their sections and in general communicate with the administrative side of our community.

Faculty will use their ports for some of the following:

☐ Conduct their own research either on M.I.T. machines or on machines at other sites.

☐ With the aid of secretaries, prepare or make corrections on class notes and homework assignments.

☐ Electronically disseminate such course material to their students.
☐ Review the work submitted by students.
☐ Prepare and review reports and other technical publications.
☐ Communicate with colleagues, administrators, and other members of our community in a paperless fashion.
☐ Maintain and coordinate their appointments, phone-directory data bases, and other plans.
☐ Monitor aggregate class parameters and the progress of individual students.

Besides performing many of the foregoing functions, administrators and other members of our community will use their ports to:
☐ Communicate with each other.
☐ Perform more effectively budgeting, expense monitoring, proposal and report developing cycles and other administrative functions.
☐ Transfer documents from their electronic stored form to graphic-arts-quality prints.
☐ Access the Institute's shared data bases on information of common interest — for example, catalog data, electronic mail, addresses of other community members, forthcoming events, and so forth.

In proposing this scenario, the committee noted that "a good deal of what is described is already happening on a very small scale within M.I.T." In the same sense, there will be pioneering users of new techniques in 1989: "one can imagine considerably more far-fetched uses of computers in the late 1980s." The committee sought a compromise, it said, "between today's forefront certainties and more futuristic viewpoints."

A Linguist's Memories of a Month in Peking: Friendly, Playful People

"An intense but limited experience", is the way Wayne O'Neil, professor of literature in the Department of Linguistics and Philosophy, describes his month-long trip to China to teach linguistics last January. He shared his experience at an informal seminar last March in the Division for Study and Research in Education. Some of his observations, paraphrased:

Since 1976, the end of the Cultural Revolution, China has been turning to the West to recruit so-called foreign experts to help her modernize. As one such visitor, I was housed with other experts in a "friendship guest house" in Peking. It was referred to locally as the "golden ghetto" because we lived there in comparative luxury. The Chinese understood that foreigners would be reluctant to accept the customary Chinese living conditions of few amenities and little privacy; a Chinese faculty member, married and with one child, for example, would have one room in an apartment and share a kitchen, bathroom, and utilities. Students live seven or eight to a room. Classrooms are not heated — the only virtue of being inside is that there's no wind. Everyone sits in coats, looking like they're ready to leave.

Professor is Idolized

I was invited to run a month-long workshop on linguistics and language teaching for English speakers. I introduced my students to the theory of language and tried to connect that with language teaching. We met for about four hours a day, four days a week.

I was also asked — at unexpected times — to give lectures to perhaps 300 people in a lecture hall. At the beginning of the first of these lectures, I went to write on the board and everyone gasped. I couldn't imagine what I had done, until it was explained to me that no one is left-handed in China (and I am). It was a constant matter of discussion. You do it so well, they said. The idea that someone could use chopsticks efficiently with a left hand amazed them. I began to feel like a very talented person.

There is a tendency among students in China to give no feedback at all to a lecturer. The question-and-answer period is likely to be a period of silence; no one will say anything to embarrass the lecturer or the students. I tried planting questioners and invited students to remain anonymous by writing queries to be read and answered in class by the professor. The students opened up — but never to the extent of being critical. We had no interchange to work things out and explore new ideas.

I was dealing with educational workers — teachers — with limited education. They held me in awe — I was to be dealt with carefully. (I possessed a powerful weapon of transformational grammar.) They had no respect for an "I don't know" response on my part. You're an expert — you've got to know, they insisted.

No Waiting in Line

In China the university is a place to *live* and work, and people don't stray outside its boundaries often. Yet I was free to go anywhere, anytime, in Peking. They were afraid that I'd become lost, but I've never been lost in my life. I took their crazy buses (which no foreigners ride) and wandered freely around the city, phrase book and map in hand. They wanted me to see their greater and better sights — antiquities. But I was content to walk, talk, and dodge bicycles. I'm average height, yet I was conspicuously head-and-shoulders taller than most people.

Although I'm familiar with China's politics and history, I wasn't prepared for how poor the country is. In a society where things are in very short supply, there is a sense that everyone wants to be first; there is no orderly waiting. It's all good natured, but each man is for himself. If you are polite and wait at the bus, you will not get home; if you push and shove, twice as many will get on. In a restaurant, you must scout for a place to sit and find your own chair. You are contending with people that came after you, and also have no sense of waiting in line. One reason the Chinese want to keep Westerners out of restaurants and buses is their fear of offending visitors in this good-natured competitive environment.

Russian Threat

People were prideful and joyful about the way they spent the period of the Cultural Revolution. Many spent five years herding sheep in Inner Mongolia, some were in prison; yet they talked about it in a lyrical fashion. I felt that while people denounced that period, they really valued it. And although they were violently anti-Western during that time, they didn't stop receiving Western periodicals.

The overwhelming feeling now is of being under the gun of Russia; war with Russia is not just a possibility but an inevitability. The Afghanistan invasion, to the Chinese, is another stage of encirclement, creating another unfriendly border. There is a sense that there is nothing else to do but get ready. The Cultural Revolution weakened China's defense ability, so short-term sacrifices must now be made to catch up.

Basically Like Us

I felt at home with the Chinese people, Professor O'Neal says, and I felt I opened them up to thinking about language and about people in ways they hadn't been before. I found them basically like us (although they don't touch): open, friendly, noisy, playful, participating always with happiness and joy.— *M.L.*

Political Scientists Are Entering the Real World; What's It Like Out There?

For at least three decades since World War II, political science at M.I.T. has been an academic science, content to let the other social sciences — notably economics and psychology — dominate the pragmatic world of making policy and making money.

Now that's changing.

As recently as 1977, 84 percent of M.I.T.'s Ph.D. graduates in political science took academic jobs — the kind of jobs which they and their teachers tended to regard as "the best possible goal." Two years later that figure was sharply down to 50 percent, and political science graduates were taking their skills into the arenas where the action is — in government, in Congress, even in industry . . . "a period of great change" for the profession, says Professor Alan A. Altshuler, head of the department at M.I.T.

Thinking that educational programs for future political scientists must respond to this changing state of affairs, Professor Altshuler and his colleagues invited a score or more of alumni who have pioneered non-academic careers to return to Cambridge late last winter to share some hard questions. Has this department a new and different mission? If so, how shall it be fulfilled?

A few of their comments:

Clark C. Abt, '51, president of Abt Associates, Cambridge: The problem is real: too few political scientists are prepared to do good research, to interpret its results, and to explain its consequences. Technology has caused a "revolution" in the social sciences during the 1960s and 1970s, says Dr. Abt. New ways of gathering and processing social data mean that we can "apply statistics and experimental design to large-scale social research in an unprecedented way." But much of this technology lies wasting because "it's still possible to earn a Ph.D. in political science without knowing statistics, econometrics, and how to sell a decent research design to a would-be sponsor."

Stanley J. Heginbotham, Ph.D.'70, assistant chief of the Foreign Affairs and National Defense Division, Congressional Research Service (Library of Congress): For a Congressional job, a political scientist has to understand organizational dynamics. You must anticipate how people — in Congress, for example — will behave. You must write for the layman, translating from academic jargon into readable programs. And you must produce useful material under difficult circumstances. (Every panel member cited the need to work well under pressure.)

David S. Mundel, '66, deputy assitant director of the Congressional Budget Office: We look for people who are not content to simply "digest facts; they want to look for cause and effect. Our clients need a picture of a very complex world," said Dr. Mundel, "but they are not adept at building models. So we look for people who like to build a world structure, with a high degree of quantitative skill. You must be able to understand a hypothesis and the biases in different techniques of acquiring data." Dr. Mundel's favorite political scientists are also those who can communicate their results; who can "write well and talk articulately. . . . When the staff and I write a report, we do it on an average of ten times. At M.I.T. I was never asked to rewrite."

Joel A. Rosenblatt, Ph.D.'72, president of the Synectics Group: Dr. Rosenblatt began his Washington career with the National Science Foundation and later moved into the private sector — a hard transition, he said: "Business is not interested if you can't deal with making a profit. . . . Working in the government is a luxury, because there is little revenue responsibility." So the new breed of political scientist has to be aware of costs: "In consulting, you must do the work within a budget, or die."

Herbert L. Selesnick, '62, vice president of Harbridge House: The business community that Mr. Selesnick represents thinks of new employees in relation to a particular assignment. "We seek solid, substantial technical skill in a small area of expertise, such as computer research," he said. Perhaps the most important single skill is conceptualization — "pattern recognition," he called it. And he likes to see these solid skills reflected in a thesis: "Take a major project from beginning to end, go through the self-discipline and agony of something difficult."

Deborah Hensler, Ph.D.'73, associate head of the Social Science Department at Rand Corp.: In contrast to Mr. Selesnick, Dr. Hensler emphasizes breadth: "We're interested in long-term potential so that when we move to a new area the person can move with us." She urges "good analytic skills" as well as training in economics and psychology. "I would like to see a political science candidate with an interest in institutional analysis, an orientation toward process, and quantitative skills." — *M.L., J.M.*

I Do and I Understand

by John Molitoris, '80

I hear and I forget.
I see and I remember.
I do and I understand.
Confucius

"The greatest disadvantage of being an undergraduate at M.I.T. is the fact that you can't do research." When I heard this I could not believe my ears. It was such a ridiculous statement that I did not know whether to laugh or hit this guy with my bowl of spaghetti (I was eating at the time). I decided to laugh. My antagonist, a physics major at another major university, did not quite know how to respond to my laughter. I finished arguing with the fellow over supper. I couldn't do much more than tell him about the undergraduate research program at M.I.T. and relate my experiences and those of my friends. I have been doing undergraduate research in physics for the past three years. He seemed to think that I was overelaborating on something that was really very limited. When he went away he still didn't believe that an undergraduate could do research at M.I.T.

This was last summer and I was in California doing work at Lawrence Berkeley Laboratory, a job which I obtained through UROP (Undergraduate Research Opportunities Program) at M.I.T. The previous fall I was helping an M.I.T. professor design a magnetic spectrograph for Lawrence Berkeley Laboratory. From my involvement in this I met a scientist from Berkeley who offered me a summer job. The only thing that enabled me to take that job was the experience I gained through my research. In fact, at no place but M.I.T. would this situation have occured. Where else could a student work with a professor who is the world's expert on magnetic spectrographs and "ion optics"?

My first experience with UROP was during the last part of my first semester at M.I.T. A post-doc, Karl Van Bibber, who then was the administrator of the freshman physics course, told me about his research. He later took me on a tour of the Van de Graaff Laboratory, otherwise known as the O.N.R. Generator (O.N.R. stands for Office of Naval Research, an artifact of the days following World War II when the military instead of the Department of Energy and the National Science Foundation ran accelerators). The Van de Graaff was pretty interesting. Although it was a decommissioned accelerator, all of the parts were still there. Karl explained how it worked (my first lesson on accelerator physics) and what kind of physics one could do with it. I got the message: even a freshman can get involved in research at M.I.T. So I did, and what followed was three years of hard work, learning, friendships that will last a lifetime, and a multitude of experiences that have become part of my life at M.I.T.

I have compared notes with a number of fellow-students about work and the lab environment, and I've found that there are distinct similarities in the "character" of each research group. Every group, for instance, has a fellow who does not have a Ph.D. The lack of the degree arises from a multitude of reasons: the war, or perhaps finances. This fellow has an incredible amount of knowledge and experience, he is as dependable as a quartz clock, and he wields a screwdriver with the same dexterity as he performs an experiment. He knows all the "ins and outs" of the lab, from where you have to kick a vacuum pump to make it work to where you have to kick a student to make him work and everything in between (i.e. the night spots around the national lab where you do experiments). He also has an unbelievable collection of stories and can remember when the chairman of the department worked in the lab and didn't know which end of the screwdriver to use. Everyone calls him by his nickname, be it "Speed," "Puff" or "Spud."

Then there are the technicians; they keep the place running. They know what their jobs are and how to do them better than anyone else. These guys always get you out of a bind. If you break an expensive casting, they can weld it vacuum tight and good as new. If you need a part they can make it. But the one thing one learns about technicians is never to rush them. They take an immense amount of pride in their work and they always make the extra effort to do things perfectly. I've seen many technicians scowl at quick, sloppy jobs.

The graduate students have all the answers, even when you don't have all the questions! They are either studying for their general exams or have just taken them and are a fine source of information. They tease you, praise you, advise you on graduate school and keep you in line. You confide in them and help them with their theses. Graduate students are your best friends.

The backbone of any group is the professor you work with. He brings all these people together and keeps them working as a unit. It sounds like the military, but it is a different kind of leadership. The professor always knows what to do, even when there appears to be a brick wall in the way. Once, a graduate student and I built an ionization chamber the size of a coffee can. This cylindrical chamber was supposed to slip smoothly into another chamber, but the welds inside the other chamber prevented this. We filed the inside of the other chamber for hours trying to get the proper fit. Then the professor we worked with came along and asked if he could try it. He took exactly *four* sweeps of the file and the ionization chamber slipped right in.

A research group gets to be like a second family. The people become more than friends, and at times I've had a few father-figures. The ties are very close; it's all part of working together towards a common goal. The sad thing about being a student is that while the main core of the group stays on, you are transient.

Lately I've divorced myself from playing around in the lab. Instead I hibernate in a quiet office in Building 20, writing and researching my thesis and then going to see the man who gave me the idea, for his criticism, advice, and direction. The professor (call him thesis advisor, research supervisor, etc.) is really quite a person. He brings you full circle: from an independent person with no knowledge of a field to an independent person with a solid background and a direction. You come without him and you leave without him, but what's in between is unique. I wonder how many people never experience this.

Incidentally, the guy who I argued with at the beginning of this article didn't have to do a thesis to graduate.

Whitaker Health Sciences Fund: A Catalytic Fund for Biomedicine Celebrates its Sixth Anniversary

Why create a half-million dollar fund for biomedical research at M.I.T. when literally billions were available from the National Institutes of Health (N.I.H.) for similar purposes?

Lots of people — including Irwin W. Sizer, then dean of the Graduate School — asked that question back in 1974. The late Uncas A. Whitaker, '23, whose half-million was at stake, had the answer: N.I.H. money came in big lumps for big projects from people who hardly knew the local scene at all. A health sciences fund was needed to support young people at M.I.T.— graduate students and junior faculty — on the basis of their ability to do creative research, and to fund new research ideas whose potential had yet to be proven.

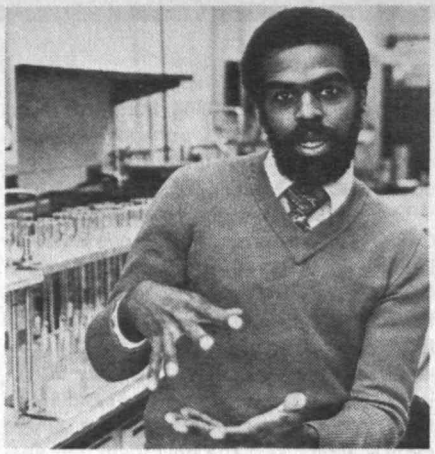
Before long, George W. Thorn, Hershey Professor Emeritus at the Harvard Medical School and a member of the M.I.T. Corporation, and Irwin Sizer himself were convinced; both became enthusiastic champions of Mr. Whitaker's idea. And, ultimately, Dr. Sizer became president and Dr. Thorn vice president of the Health Sciences Fund, renamed the Whitaker Health Sciences Fund In February, 1978, in honor of its founder.

In the first year, with $250,000 made available by Mr. Whitaker, the fund awarded six doctoral research fellowships and seven faculty research grants for a total commitment of $245,000.

Six years later, with Mrs. Helen Whitaker succeeding her late husband as trustee of the fund, the operating budget is more than $700,000, supporting 15 young scientists and 19 faculty members. These represent 10 M.I.T. doctoral fellowships, five fellowships for doctoral candidates in the Whitaker College of Health Sciences, Technology and Management of M.I.T., ten M.I.T. faculty research grants, and five Harvard-M.I.T. collaborative research grants. (Work done by two of the 1979-80 Whitaker fellows is described in the adjoining columns).

As of October, 1979, the Fund has supported 48 doctoral fellowships and 95 faculty grants for research in the life sciences and medicine at M.I.T., with collaboration in some cases at Harvard Medical School and the Boston University School of Medicine. The fund has been "a strong positive force in stimulating biomedical research and education in the Boston area," says Professor Sizer, "and it has had a most favorable impact . . . a cataytic effect on the research and on the careers of the young scientists who have been supported."

The same catalytic effect has been felt by the universities involved, Dr. Sizer says, since many of the activities that were originally fostered by the fund have resulted in significant biomedical achievements which have gone on to qualify for larger federal funding. Furthermore, with the deterioration of federal support of research over the past several years, coupled with a rising inflation, the value of the fellowships and research grants from the Whitaker Health Sciences Fund have exceeded that anticipated by its supporters in 1974.



As the fund enters its seventh year, the procedures for the selection of fellows and faculty awards continue as they were initially laid down. According to Dr. Sizer, the Selection Committees (made up of review committees of senior faculty members and deans of the three universities) attempt to achieve a breadth of coverage to encourage biomedial research of all kinds from all the major disciplines. "We try to consider anything that, by the broadest stretch of the imagination, could be called life sciences and medicine," he explains. "This can include anything from harbor pollution to the development of cancer drugs . . . anything that adds to the benefit of mankind or the the advancement of the biomedical field."

In past years topics that have caught the eye of the Selection Committee include: water movement in salt marshes; a study of speech of the profoundly deaf; the control of a monkey's eye movement using computer language; the role of copper enzymes in biochemical activities; Soviet and American vocational rehabilitation services; an inhibitor for sickle cell anemia; brain changes following strokes; acetylcholine receptors in insect brains; and the growth and toxin production of red tide organisms.

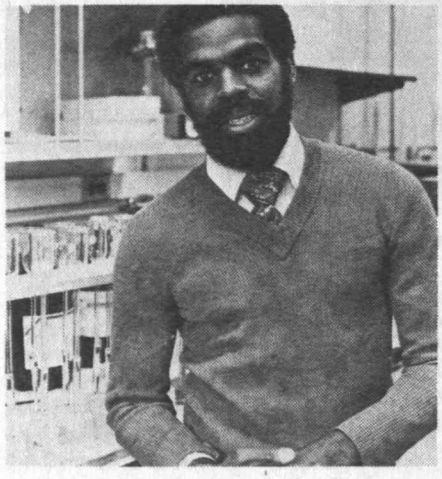
The 1980 awards, effective next July, will support student and faculty studies in molecular genetics, human amino acid metabolism, the age dependence of human cancer, the synthesis of an artificial human pancreas, and the effects of acid precipitation on a wetland.

The catastrophic electrical accident of the heart known as "sudden death" is being studied by Neal A. Scott, graduate student. He is using this riddle as the basis for his doctoral thesis with support from the Whitaker Health Sciences Fund.

"Sudden Death": The Fatal Link from Brain to Heart

Though it lies at the very center of the complex jigsaw of human body function, the region of the heart remains among the more mysterious parts of the puzzle. As if things weren't difficult enough, the puzzle itself has overlapping pieces; even major organs such as the heart cannot be studied alone. To solve the part of the puzzle that is the human heart, it now appears advisable to look for some pieces that overlap with the brain.

Case in point: recent research into the catastrophic electrical accident of the heart known as "sudden death." Sudden death is



the result of a devastating arrythmia called ventricular fibrillation (VF). It is a major killer in the 20-to-64 age group, a dramatic, dangerous malfunction that strikes even people who seem in perfect health, have absolutely clean coronary arteries, and, indeed, have no apparent symptoms whatsoever of cardiac malfunction.

When the heart goes into VF, the normal synchronization of its longitudinally arranged fibers is interrupted. The heart muscles move chaotically, each one contracting and relaxing at its own pace, looking very much like "a bag of worms," as one researcher described it. Death occurs within minutes — hence the name sudden death — unless cardiopulmonary resuscitation and defibrillation are immediately instituted.

A promising avenue of research in sudden death links the heart with the nervous system. It has long been known that certain neurotransmitters in the central nervous system (the brain and the spinal cord) can modify the activity of cardiac muscles by affecting the sympathetic nervous system. Sympathetic neural activity is that which responds primarily to situations of danger or excitement by releasing adrenalin, thereby causing the heart rate to increase, the pupils to dilate, and metabolic sugars to be changed.

Recent research has shown that the sympathetic system can also predispose the heart to VF. Conversely, it appears that the heart can be protected against VF by reducing sympathetic activity and by increasing

certain central nervous system neurotransmitters that seem to protect the heart. The challenge is to determine just which neurotransmitters have this protective effect and to elucidate how they do it.

Using this riddle as the basis for his doctoral thesis, with support from the Whitaker Health Sciences Fund, Neal A. Scott has been studying the effects of tyrosine, an amino acid that is the precursor of norepinephrine. Norepinephrine, in turn, is one of the primary neurotransmitters involved in protecting the heart against VF.

It is known that increased levels of certain neutral amino acids in the blood (tyrosine among them) can cross the blood/brain barrier and result in increased levels of these

amino acids in the brain. The ultimate question is: Can these interrelationships be manipulated to either raise or lower the heart's electrical threshold in the development of VF?

In preliminary studies tyrosine appears to have the beneficial effect of raising the electrical threshold, but how it acts and what mechanisms are involved from its incorporation into norepinephrine in the brain to norepinephrine's interaction with the heart have yet to be clearly determined. This remains Scott's principal challenge as he continues his thesis research under Drs. Richard Wurtman, professor of endocrinology and metabolism at M.I.T., and Bernard Lown, professor of cardiology at the Harvard School of Public Health.

Scott cautions that this work is still very preliminary, far from clinical application. His hope is to add further insight into research that may someday lead to a drug that can protect the heart against electrical accidents like sudden death and to a clinically practical method to identify those at risk from what now appears a relatively risk-free population.— *Suzanne Olson*

As a doctoral candidate in mechanical engineering, Boris Rubinsky is exploring an unruly problem of biochemistry: freezing and thawing living organs. He is designing an analytical model for organ cryopreservation. (Photos, pages A14, A15: James J. Snyder, '80)

How to Revive a Frozen Organ

Living cells and small pieces of tissue can survive freezing and thawing when protected by glycerol. That discovery arose by accident over 30 years ago and led to the development of modern banking methods for blood and other cells and tissue. Similar success using cryopreservative agents like glycerol to freeze and bank organs seemed surely to follow. But it hasn't happened: the secret to successful freezing and thawing of living organs remains frustratingly elusive.

Enter a new group of actors from what may seem at first glance a rather inappropriate troupe for the study of organ freezing: mechanical engineers. But to Boris Rubinsky, a doctoral candidate in the field at M.I.T., it just makes sense.

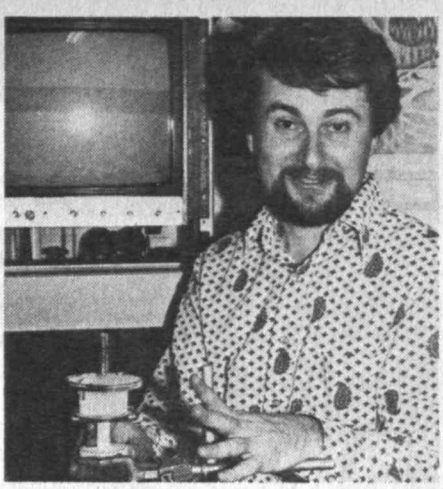
"Once you look at nature," he maintains, "you cannot distinguish separate fields — especially in biology which is nature itself. You need large amounts of knowledge coming in from various points of view."

It is through its emphasis on the analytical approach that Rubinsky believes mechanical engineering can help shed light on this unruly problem of biochemistry. His goal is to design an analytical model for organ cryopreservation upon which experimental studies can be built.

This ultimate intention in mind, Rubinsky has studied the three main variables involved in banking organs — the rate of cooling (freezing), the concentration of the cryopreservative agent (called the cryophylactic agent, or CPA), and the rate of heating (thawing). What he found was serious flaws with the generally accepted standards for all three of the critical variables.

For example, previous investigators assumed that the CPA was distributed uniformly among the cells of the organ at the end of a typical CPA introduction protocol. Not so, says Rubinsky. By studying the diffusion control processes in rat hearts, he found the time allowed for introduction of CPA insufficient. As the concentration of CPA is directly linked to the survival of the cells during freezing and thawing, such miscalculations might easily explain the continued failure in organ cryopreservation. One result of these analyses is a simple new method for estimating the time required for complete introduction of the CPA. Rubinsky says he has devised a more detailed model that will enable the actual concentration of CPA in the organ to be determined and controlled.

Miscalculations involving cooling and thawing rates have also come to light under Rubinsky's analyticial scrutiny. Present methods to freeze organs again assume homogeneity throughout the organ. Rubinsky's studies have shown, however, that there is no such homogeneity: the cooling rate within an organ can vary greatly depending on the experiment. Homogeneous cooling in an organ the size of a human heart is an impossibility, Rubinsky says, but with his new analyses, "we can now estimate the whole range of cooling rates and design correct methods of freezing."



Managing the thawing rate is even more frustrating than managing the cooling rate, Rubinsky found. His results show, for example, that the rate of thawing at the region near the center of an organ is virtually independent of the amount and timing of the heat applied at the outer surface. Present methods of thawing have organs placed in either a water bath or running water — the optimum temperature of the water still a matter of debate.

The problem here, Rubinsky explains, is that the outer surface of the organ cannot be heated above 40 °C. or damage will occur. "You can literally cook it," he says. As the temperature outside the organ must be kept low to prevent damage to the surface, another problem arises — this one the result of keeping the interior tissues too long at the critical region of temperature where ice turns to liquid. It is at this range that damage to the cell due to differences in thermal properties of ice and liquid is most likely to occur.

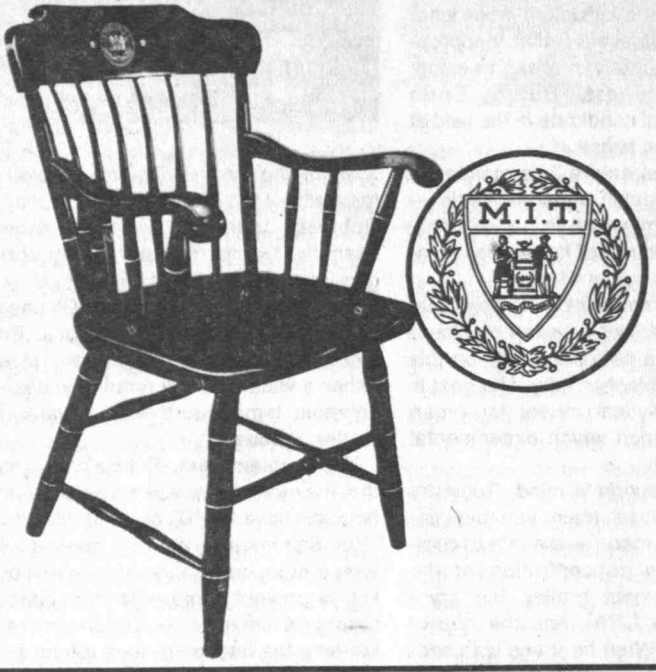
"What we need," Rubinsky concludes, "is a new method for thawing the organ — perhaps microwave or maybe ultrasound."

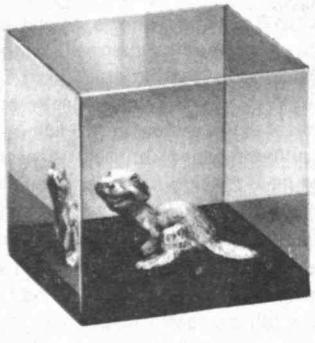
By demonstrating the mistakes of the past, the analytical approach of mechanical engineering in organ cryopreservation research already seems to have proven itself of value. But Rubinsky says it is allowing him to take the research a large step further: to prescribe a protocol for introducing the CPA in the correct amounts of time and concentration; to control the cooling rate; and to aid in designing a new method of thawing.

Thus far Rubinsky's efforts, supported by the Whitaker Health Sciences Fund and carried out under the supervision of Ernest G. Cravalho, Matsushita Professor of Mechanical Engineering in Medicine, have been confined almost entirely to analysis. But now he is making plans for experiments on animal organs to "see if we've found the correct protocols or if we need to look further." — *Suzanne Olson*

M.I.T. INSIGNIA

A GOOD WAY TO REMEMBER





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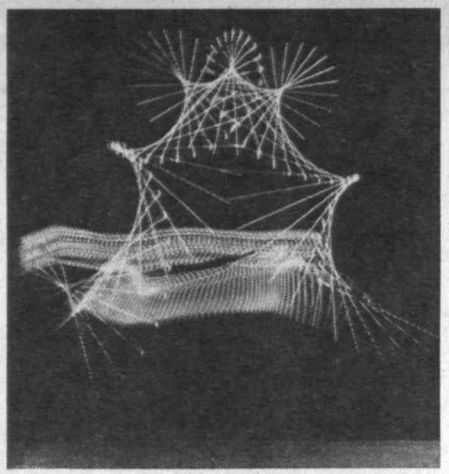
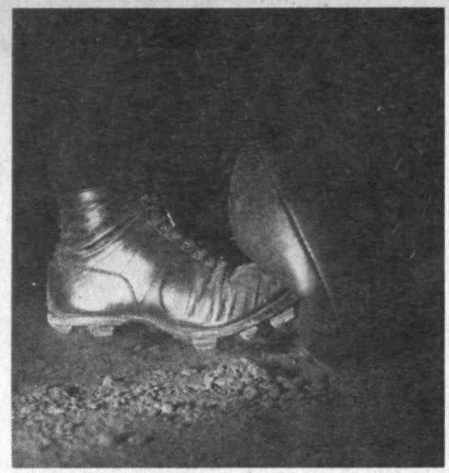
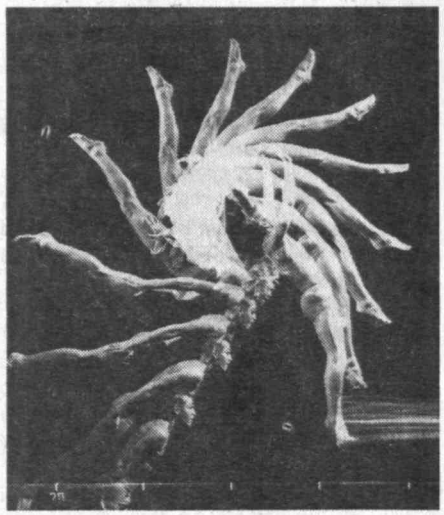
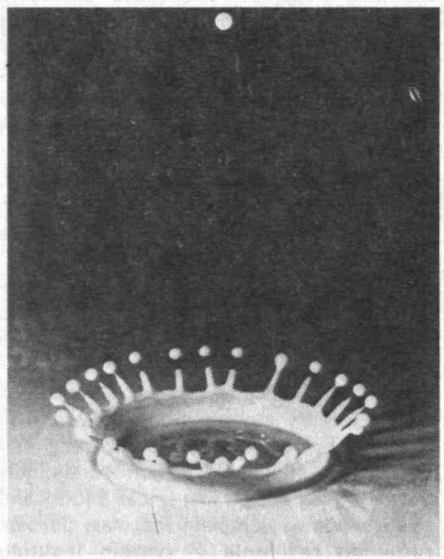








No images more universally understood than "Doc" Edgerton's photographs have come from any other university in the past half-decade, perhaps ever. Now these pictures and many more, and the stories of how they were made, are recorded by the photographer and one of his principal admirers in Moments of Vision.

The Story of "Papa Flash"

Moments of Vision, by Harold E. Edgerton and James R. Killian, Jr. Cambridge: the M.I.T. Press, 1979. $20.

Reviewed by Volta W. Torrey

Fame and a fortune began to reward Harold Edgerton, Sc.D.'31, in the 1930s. He had come to M.I.T. as a graduate student from the middle of America's great plains after gaining a few years' experience as an electrician and engineer. He wanted to better understand the behavior of a whirling rotor in a synchronous generator or motor, and to do that he devised a system to photograph it in action as if it were standing still. The quick flash of very bright light he threw on his rotor started a revolution in stroboscopic photography.

Soon Harold Edgerton was using his flashes to show other things than machinery at work — the impact of golf club on ball, a diver on water. James R. Killian, Jr., '26, *Technology Review*'s most astute editor, soon saw and published the pictures Harold began to take. Gjon Mili, '27, borrowed his apparatus to photograph a dancer in motion and was instantly converted. Those pictures soon brought photographers, scientists, and artists from everywhere to the always-open-door of "Doc" Edgerton's workshop.

With two of his admirers, Kenneth Germeshausen, '31, and Harold Greer, "Doc" went into business, and the firm they started is now listed on the New York Stock Exchange as EG&G. But Harold refused to become a captain of industry. He went on teaching and experimenting in his shop — and soon he became as fine an example of the teacher devoted to his students and his laboratory as M.I.T. ever had. Given the rank of Institute Professor in 1970, he is now a professor emeritus. But you can still find him in his crowded shop near the library under M.I.T.'s Great Dome nearly every day — unless he is off somewhere to help someone expose more of our planet's infinite mysteries.

During World War II Professor Edgerton designed and built a 40,000-watt-second xenon flash lamp for night aerial reconnaissance. After the war he took enlightening pictures of explosions at Bikini and Las Vegas. He then began to produce underwater cameras, lights, and a sonar "pinger" to enable oceanographers both to see and feel the earth the oceans hide.

Moments of Vision is a novel kind of memoir that its authors have dedicated to Professor Edgerton's long list of friends. It is mostly pictures, made doubly interesting by Dr. Killian's warm tribute and concise commentary. In the simplest possible terms, the text explains how "Doc" split time into millionths of a second, reviews his career, and stresses the impact of his work on both science and art.

You have surely seen the frontispiece before. It is Harold's photo of the tiny crown created for a fraction of a second when he let a drop of milk fall onto a thin layer of milk. It is followed here by scores of glimpses of animate and inanimate things in motion. These include athletes and acrobats, birds, beasts, and bugs, fish, dancers and singers, bullets, atomic blasts, and fascinating phenomena on the floor of the sea. Appropriately, the first and last pictures in the book are of "Doc" Edgerton himself.

Gjon Mili has called Edgerton "an American original." Jacques Cousteau has dubbed him "Papa Flash." Killian considers him "a masterpiece" among men. In *Who's Who* he lists himself only as an educator and electrical engineer. Wherever he turns, he finds teaching and pioneering irresistible.

His former students flock to hear him whenever they can. He always has a pack of pictures in his pocket to hand out like calling cards. You are likely to learn something new — and enjoy it — whenever you meet him. While we were reminiscing in his parlor one evening, Professor Edgerton taught my son to play a guitar. On a long oceanographic voyage with Russian scientists, Professor Edgerton taught them to sing "She'll be comin' round the mountain when she comes," and he in turn learned a few Russian ditties from them.

If your doctor or any other professional man keeps you waiting in his reception room, give him *Moments of Vision*. Thereafter, waiting will be a pleasure.

Volta Torrey first met Professor Edgerton nearly 60 years ago when both were growing up in Nebraska. He was editor of Technology Review *from 1959 to 1966.*

Under the Domes

Spring returns to Killian Court. (Photo: Calvin Campbell)

A Triple Blow from Inflation: Tuition, Housing, and Equity Up

It's been a hard spring for M.I.T. students calculating their 1980-81 expenses.

Tuition will be up $900, to $6,200, effective next fall.

Increases in the cost of room and board will bring the total of a typical student's budget for the year to just under $10,000.

The "equity level" — the amount (including loans, savings, and term-time jobs) a student and parents must provide toward educational expenses before scholarship assistance becomes available — will be $3,000 for 1980-81 — up from $2,650 this year.

The tuition increase — 17 percent — is a big one compared with those of recent years. It results from the combined effects of unexpected inflation during the current year and expected inflation in 1980-81. A year ago tuition went up 8.5 percent while inflation finally came in at a 13-percent annual rate; and no one thinks it will be much less this year. As President Jerome B. Wiesner told *Chronicle of Higher Education*, M.I.T. is "the victim of last year's shortfalls and next year's double-digit predictions." And M.I.T. is "singularly vulnerable" because the Institute is energy-intensive, and the cost of energy is rising faster than the average of all prices.

For similar reasons, the cost of room and board will be steeply up next year. (In 1978-79, energy cost $256 out of each resident's rent in the M.I.T. dormitories; this year the cost will be just under $400.) And some students complain that new policies requiring residents in certain Institute houses to eat meals there (*see below*) will further exacerbate the rising cost of room and board.

But as the "equity level" rises, so do some of the offsets to the expenses of attending M.I.T. For example, Paul E. Gray, '54, chancellor, told *The Tech* that the guideline for salaries for students working on research projects will be $4.50 an hour by next fall (up 28 percent), which means that a student working ten hours a week for a 25-week school year can earn over $1,000. Undergraduates will be eligible for National Direct Student Loans of up to $1,200 and Guaranteed Student Loans of up to $2,500.

Adding the new increase in the cost of attending M.I.T. to those of the past four years, James A. Xanthos, '83, of *The Tech* discovered a 45 percent jump since 1975. Then he asked Robert K. Weatherall, director of career planning and placement, about the average starting salaries of recent engineering graduates: also up, by slightly more than 45 percent. Since 1975 the ratio of student budget to average starting salary has ranged from 5.22 (1979) to 5.70 (1977).

No one expects the trend of increasing cost to change in 1981-82. Indeed, Stuart H. Cowen, vice president for financial operations, told Gordon B. Hunter, '80, of *The Tech* early this year that the $900 tuition increase for 1980-81 "is a bit low. . . . My own personal judgment is that it's going to get worse" in the future.

An Inauguration in Place of an AOC

Paul E. Gray, '54, will be inaugurated as 14th president of M.I.T. at ceremonies on Friday, September 26. The usual Alumni Officers' Conference will be cancelled for 1980 so that alumni can participate in the events of the inauguration.

The latter are being planned by an Institute committee on which the Alumni Association is represented by Joseph J. Martori, director of course and class programs.

Giving Dining a Bigger Part in the Educational Experience

After a year of study, a student-faculty Committee on Campus Dining appointed by President Jerome B. Wiesner has recommended a new emphasis on community dining facilities and experiences for undergraduates.

It wants all students in houses with their own associated dining rooms — Burton, Baker, McCormick, MacGregor, East Campus, and the new house to be built in 1980-81 — to take "commons" meals, with cooking in rooms in these houses to be discouraged. The program, it said, would "help make meal times a more important part of the undergraduate residential program."

Physical improvements to dining facilities which might cost $700,000 were part of the recommendations: alterations to Pritchett Lounge, Morse Hall, and the Lobdell Room to improve service, reduce crowding, and develop the amenities typical of house dining rooms; renovate Talbot Lounge in East Campus as a "country kitchen" in which residents can prepare meals and entertain guests, and provide similar facilities in Senior House; reopen the McCormick Hall dining room; establish a food store on the campus; and improve vending machine services.

Embracing these recommendations, Paul E. Gray, '54, chancellor, has announced that freshmen in Baker and McGregor Houses next fall will be asked to accept a combined room and board plan. The dining room in McCormick Hall will be reopened, and a similar plan will be in effect there.

And to make possible this upgrading of the residential program as a significant factor in the educational experience while keeping meal prices competitive, M.I.T. will provide subsidies of $300,000 to the dining services next year, ending a long-standing "no-loss-no-gain" policy.

Student opinion — or at least that portion which could find visibility — quickly arrayed itself against the "compulsory commons" aspect of the plan. "Once again the M.I.T. administration is going to inflict a restrictive, repressive rule on a portion of the student body that cannot retaliate," wrote Michael Taviss, '81, in *The Tech*.

President-Designate Paul E. Gray, '54, has been a champion of the Undergraduate Research Opportunities Program (UROP) ever since it was founded. Naturally, then, when UROP celebrated its tenth anniversary by selling T-shirts in the Building 10 lobby this spring, Dr. Gray was on hand to do his share of the peddling. UROP will use the proceeds for a tenth-anniversary party, and Stephanie Pollack, '82, general manager of The Tech, *read still more into the story. President Jerome B. Wiesner's style has been "low-key," she wrote. But she thinks Dr. Gray will be at least more visible, and probably more accessible, as the Institute's chief executive. (Photo: Calvin Campbell)*

$1,000 from the College Bowl

After more than a year of smashing successes, the four undergraduates who made up M.I.T.'s College Bowl team went down in defeat to Washington University, St. Louis, in the national semifinals of the radio series early in March. Their winning steak had propelled them to the New England championship (over second-place Harvard) and to three victories at the national semifinals before the end came.

By making the seminfinals, the team — Brian Clouse, '80, Jeffrey Gerecht, '80, Steven Karel, '81, and Todd Eddy, '83 — won a $1,000 scholarship for M.I.T.

Nalebuff: Another Rhodes Scholar

Barry Nalebuff, '80, will go to England next fall to study economics at Nuffield College, Oxford — the winner of a 1980 Rhodes Scholarship. He's the second winner in as many years at M.I.T.; only 32 scholarships were given throughout the U.S. for 1980. Mr. Nalebuff will receive bachelor's degrees in economics and mathematics in June; he's already in England, spending his senior year at St. Catherine's College, Oxford.

Taxes: Everyone Pays

M.I.T. retained its rank as one of the largest taxpayers in Cambridge in 1979, with payments of nearly $2 million in taxes and in lieu of taxes. To reimburse the city for its services, the Institute paid $410,000 in lieu of taxes, on the basis of campus property that is exempt from taxation because it is used for educational purposes; in addition, there were taxes of $1.4 million on M.I.T.-owned property not used for educational purposes.

Tiddlywinks Popping Again

The M.I.T. tiddlywinks dynasty, dormant for at least seven years, is awakening.

The first positive evidence for that came during the winter, when a young and lightly-regarded team of M.I.T. students and alumni took in the North American Team Championships at Cornell. They missed the number-one spot by one-sixth of a point, the smallest possible margin in a tiddlywinks tournament; the winning combination was a club entry starring William H. Renke, '73.

The revitalized M.I.T. team is led by Arye Gittelman, '83; he's considered the best freshman player of all time, according to Fred Shapiro, '74, reporting for *The Tech*. So many M.I.T. freshmen are into tiddlywinks this year that observers predict the team will dominate the winking scene by next fall. Other members of this year's team include Mr. Shapiro, Richard Tacker, '80, and Ross W. Callon, Jr., '73.

David H. Lockwood, '75, still holds the world singles tiddlywinks championship.

M.I.T. Calling: Students Add $110,000 to the Fund

More than 400 students heard "yes" from 3,100 alumni during two weeks of telephoning in behalf of the Alumni Fund last winter, and the fund was enriched by over $110,000. All those numbers are above the targets set by Joseph S. Collins, director of the Alumni Fund, and his telethon expert, Brenda Hambleton, '79, when they made plans with the Alumni Fund Board late last fall.

"It's such a nice day, why don't you go fly a kite?" was one alumnus' response, and Gary Neben, '81, figured it was a classic brush-off. But it wasn't: the couple at the end of the line, both alumni, pledged $15. Lee Moriwakee, '81, started out by asking his alumni to double their last year's gifts. But the first few times the telephone provided "an incredulous response after a long silence," and Mr. Moriwakee changed his strategy.

The $100 prize put up by the Alumni Fund for the living group whose numbers were most successful at the telephones went to Zeta Beta Tau; in one long night, its members collected $12,208 in pledges. Over half of all the pledges were from alumni who hadn't given in the last five years. "That says a lot about the students' ability to solicit support for the Institute," Mr. Collins told Jack E. Link, '83, of *The Tech*. Indeed, an overall 65 percent of those called pledged to the fund, and 20 percent more (for a total of 85 percent) said they would do something before the end of the fund year on July 1.

Building 20 36 Years Later

Memories are coming alive again in the Compton Gallery — this time of Building 20, including its computers, model trains, radars, military exercises, and countless irrepressible inhabitants. A show devoted to Building 20, chronicling its history and the accomplishments of its tenants over the years since its construction in 1944, will continue in the Margaret Hutchinson Compton Gallery through June 10.

As the show makes clear, there is nothing temporary about this "temporary" building that is still going strong 36 years later.

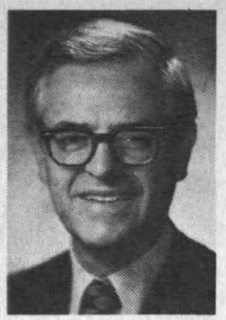
H. P. Aldrich, Jr.

C. W. Brenner

J. C. Page

M. F. Wagley

R. W. Mann



E. K. Miller, Jr.

K. J. Germeshausen

J. S. Reed

T. H. Farquhar

S. A. Jackson

Association Presidency to Aldrich; Other Alumni Leaders Named

Harl P. Aldrich, Jr., '47, is the choice of the National Selection Committee to be president of the Alumni Association for 1980-81. He'll take office next July 1, succeeding Claude W. Brenner, '47.

Dr. Aldrich is co-founder and president of Haley and Aldrich, Inc., consulting geotechnical engineers and geologists of Cambridge, Mass. For ten years following graduation he was a member of the Civil Engineering Department; he is a past president of the Boston Society of Civil Engineers and of the Massachusetts Section of the American Society of Civil Engineers. Dr. Aldrich holds the Bronze Beaver Award; he has been a director and vice president of the Alumni Association; and he serves on the Corporation Visiting Committee to the Department of Civil Engineering.

Other choices by the National Selection Committee:

☐ Nominees for alumni members of the M.I.T. Corporation for five years beginning in July, 1980: **Claude W. Brenner,** '47, 1979-80 president of the Alumni Association; **Kenneth J. Germeshausen,** '31, retired chairman of E G & G, Inc.; and **John S. Reed,** '61, senior executive vice president of Citicorp and Citibank, New York.

☐ Vice presidents of the Alumni Association (1980-82): **Jack C. Page,** '48, management consultant of Dallas, Texas; and **Mary Frances Wagley,** '47, executive director of Episcopal Social Services of the Diocese of Maryland, Inc.

☐ Directors of the Alumni Association (1980-82): **Thomas H. Farquhar,** '60, senior vice president of Massachusetts Financial Services Co. (District 1); **Shirley A. Jackson,** '68, member of the technical staff at Bell Telephone Laboratories, Inc. (District 4); **Robert W. Mann,** '50, Whitaker Professor of Biomedical Engineering at M.I.T. (District 2); and **E. Kirkbride Miller,** '41, chairman of the board and president of T. Rowe Price Associates, Inc., Baltimore, Md. (District 5).

Until early this year, Mr. Brenner was vice president-operations of the Northeast Solar Energy Center. He graduated from M.I.T. in aeronautics and astronautics, and he has had leading roles in a number of high-technology enterprises in the Greater Boston area since leaving the M.I.T. staff in 1953. Mr. Brenner was elected secretary of his class upon graduation, and he has had major leadership assignments for the Alumni Association throughout the past decade.

Mr. Germeshausen was a co-founder of Edgerton, Germeshausen, and Grier, Inc., now E G & G, Inc., and held leadership roles in the firm as vice president, president, and chairman of the board until retirement in 1972; he holds over 50 patents covering electronic circuits, flash lamps, and a variety of gaseous discharge switch tubes. A generous supporter of many M.I.T. activities, including those of the Alumni Association and his class, Mr. Germeshausen is a member of the Corporation Development Committee and the Council for the Arts; and he is an incorporator of the Neurosciences Research Foundation.

Mr. Reed joined Citibank in 1965, a year after he received his S.M. from M.I.T.'s Sloan School of Management, and he held major positions in the bank's Operating and Consumer Services Groups before taking his present post in January. A member of the Corporation Development Committee, Mr. Reed also serves on the Visiting Committee for the Sloan School of Management, and he is co-chairman for the New York City area of the M.I.T. Leadership Campaign.

Hester Resigns, and the Alumni Search for New Leadership

James A. Hester, Jr., '65, who became executive vice president of the Alumni Association late in 1978, has resigned effective July 1, and the search for a successor has begun.

In a statement to the staff, Dr. Hester said that he has "reluctantly come to the conclusion that this position cannot provide the personal and professional satisfaction essential to my performing well over the long term."

Claude W. Brenner, '47, president of the association, is reconvening the search committee of association members which originally nominated Dr. Hester; and he is confident that a successor can be found before Dr. Hester's July 1 resignation date. Alumni with comments and suggestions should send them to Richard A. Knight, '47, secretary of the association, at Room 10-110, M.I.T.

Forming the New Administration: Francis E. Low to be Provost

The new administration of M.I.T. which Paul E. Gray, '54, will lead as president beginning on July 1 began to take form this spring with three retirements and two major new appointments:

☐ **Francis E. Low**, Karl Taylor Compton Professor of Physics who is director of the Center for Theoretical Physics and of the Laboratory for Nuclear Science, will become provost of the Institute on July 1. He succeeds Professor Walter A. Rosenblith, who has held this influential post since 1971.

☐ **William R. Dickson**, '56, director of Physical Plant, will become vice president — operations on July 1, succeeding Philip A. Stoddard, '40, who will retire.

☐ **John M. Wynne**, S.M.'56, vice president — administration and personnel, left M.I.T. on March 1 to enter private business; his duties, relating principally to personnel, placement, and student financial aid administration, are being assumed by Constantine B. Simonides, '57, vice president.

As provost, Professor Low will be principal deputy to the president. He and Dr. Gray

Francis E. Low, Karl Taylor Compton Professor of Physics, has been tapped by Paul E. Gray, '54, president-designate, to serve as the president's chief deputy, beginning on July 1. He'll be responsible for academic programs, appointments and promotions in the academic and research staff, and the use and assignment of space.

Francis E. Low

will establish the Institute's policies, directions, plans and priorities affecting the academic programs, and Dr. Low will be responsible for all such on-campus programs. This includes the allocation of financial resources and space for them and the appointment and promotion of academic research staff.

Professor Low's appointment was approved by the Executive Committee of the Corporation, and Dr. Gray says "its primacy reflects its great importance to the Institute."

Dr. Gray was warm in his praise for his new provost: "Professor Low . . . has earned the confidence and respect of his colleagues, at M.I.T. and elsewhere, by his consistent concern for intellectual integrity and quality and by the quality of his judgement and his taste over a broad range of ideas and interests.

"I am confident that these qualities of mind and character will serve the Institute very well, and I relish the prospect of a long and close association with him."

Professor Low studied physics at Harvard (A.B. 1942) and Columbia (M.S. 1947, Ph.D. 1949). He came to the Institute as full professor in 1947, having before then been at the Institute for Advanced Study in Princeton and at the University of Illinois.

Physical Plant and Administration

Mr. Stoddard, whose M.I.T. degree is in management, returned to the Institute in 1948 to become assistant to the executive officer of the Instrumentation Laboratory; thereafter he held various administrative assignments in the Institute's financial and business management, assuming his present post in 1961. In nearly 20 years since then he's had a major role in planning and managing the Institute's physical plant, the size of which has doubled in that period.

Mr. Dickson, who succeeds him, has formed an effective partnership with Mr. Stoddard since 1960, when Mr. Dickson himself returned to the Institute as assistant director of physical plant; he became director in 1971, and since then he has been deeply involved in programs to conserve energy and increase efficiency in physical plant operations.

Mr. Wynne first came to the M.I.T. in 1955 as a Sloan Fellow for the one-year intensive course in the Sloan School of Management. Two years later he was back at the Sloan School to direct the Executive Development Programs in which he had been a student. He became the school's associate dean in 1961, and in 1967 he was named a vice president of the Institute.

Engineering Academy Elections

Twenty-one of the 90 engineers elected to the National Academy of Engineering this spring are members of the M.I.T. community. Election to the academy is "the highest professional distinction" that can come to an engineer, a recognition of "important contributions" to theory and practice.

The new members from M.I.T.:

Donald J. Atwood, '48, vice president, General Motors Corp., and general manager of its Detroit Diesel Allison Division.

Eugene E. Covert, Sc.D.'58, professor of aeronautics and astronautics, M.I.T.

Jose B. Cruz, Jr., S.M.'56, professor of electrical engineering and director of the Decision and Control Laboratory, University of Illinois.

Robert G. Dean, Sc.D.'59, professor of civil engineering, University of Delaware.

Leslie C. Dirks, '58, deputy director for science and technology, Central Intelligence Agency.

Nicholas J. Grant, Sc.D.'44, professor of materials science and engineering, M.I.T.

Karl U. Ingard, Ph.D.'50, professor of aeronautics and astronautics and of physics, M.I.T.

Leonard Kleinrock, Ph.D.'63, professor of computer science, University of California, Los Angeles.

Wesley A. Kuhrt, '39, senior vice president — technology, United Technologies Corp.

Robert A. Laudise, Ph.D.'56, director of the Physical and Inorganic Chemistry Research Laboratory, Bell Telephone Laboratories, Inc.

Charles J. McMahon, Jr., Sc.D.'63, professor of metallurgy and materials science, University of Pennsylvania.

Harry W. Mergler, '45, Leonard Case

Professor of Electrical Engineering, Case Western Reserve University.
Robert C. Reid, Sc.D.'54, professor of chemical engineering, M.I.T.
Herbert H. Richardson, '53, head of the Department of Mechanical Engineering, M.I.T.
Gordon Robeck, S.M.'50, director of the Drinking Water Research Division, U.S. Environmental Protection Agency.
Ernest W. Thiele, '23, consulting engineer of Evanston, Ill.
Gregory S. Vassell, '69, senior vice president — system planning, American Electric Power Service Corp.
Gerald L. Wilson, '61, head of the Department of Electrical Engineering and Computer Science, M.I.T.
Holden W. Withington, '39, vice president — engineering, Boeing Commercial Airplane Co.
Laurence R. Young, '57, professor of aeronautics and astronautics and director of the Man-Vehicle Laboratory, M.I.T.

In addition, **Victor F.B. de Mello,** '47, consulting engineer of Sao Paulo, Brazil, was named a foreign associate of the academy.

Ramon Cassaprima, 1960-1979

Ramon Cassaprima, '81, former treasurer of Delta Upsilon fraternity, died of cancer in New York on November 20, 1979; he was 20.

Mr. Cassaprima had withdrawn from M.I.T. late last spring for treatment in New York. He returned to classes as a junior last fall, but he was recalled to the Sloan-Kettering Memorial Cancer Center shortly after the beginning of the term.

Nathan Wall, 1925-1979

Nathan Wall, Ph.D. '54, who taught in the Department of Physics at M.I.T. from 1955 to 1961 and then joined the Laboratory for Nuclear Science for three years, died in Baltimore, Md., on September 2; he was 54. At the time of his death, Dr. Wall was professor of physics at the University of Maryland.

Harold L. Hazen, 1901-1980: A "Major Figure" in M.I.T. History

Harold L. Hazen, '24, dean emeritus of the Graduate School who headed the Department of Electrical Engineering for 14 years beginning in 1938, died suddenly at his home in Belmont on February 21. He was 78.

President Jerome B. Wiesner said Dr. Hazen "stood among the major figures in M.I.T.'s modern history. The legacy of his engineering genius is imbedded in contemporary control systems and in pioneering computer technology. His seminal contributions in the field of automatic control and his dedication to research as the basis of advanced education were important building blocks in the development of M.I.T. . . . He influenced significantly the quality of engineering education on an international scale."

At a memorial service on February 23, President Wiesner added yet another tribute: ". . . one of the most beloved men who ever graced the halls of M.I.T."

And Professor Emeritus Gordon S. Brown, '32, who succeeded Dr. Hazen as department head in 1952, cited his "profound and beneficial influence" toward making M.I.T. "a place where every teacher meets every student more than half way." Dr. Hazen's principal thrust as department head, said Dr. Brown, had been "to maximize the productivity of others."

Dean Hazen came to M.I.T. in 1920 to study electrical engineering, and his whole professional life following graduate study (S.M. 1929, Sc.D. 1931) was spent at the Institute except for one year (1934-35) on an exchange professorship at Ohio State University. As a young member of the department, Dr. Hazen worked with the late Vannevar Bush, '16, on problems in computing and automatic control, and in 1935 he received the Franklin Institute's Levy Gold Medal for papers on the theory and design of servomechanisms.

Later, as head of the Department of Electrical Engineering and dean of the Graduate School (1952-67), he was active in the Engineers Council for Professional Development (from which he received the Grinter Distinguished Service Award in 1975), in the American Society for Engineering Education, as a trustee of Robert College, Istanbul, as a leader of an engineering education mission to Japan, and as a trustee of the College (now University) of Petroleum and Minerals at Dhahran, Saudi Arabia.

Dr. Hazen's survivors include his wife, Katherine (Salisbury), '28, four children (including Nathan L. Hazen, '56) and eight grandchildren.

John C. Chen, 1962-1980

John C. Chen, '83, who pledged Phi Delta Theta when he arrived on the campus as a freshman last fall, died of cancer on January 22 after an illness of three months. He was 18.

Mr. Chen entered M.I.T. from Cherry Hill, N.J., and was respected by those who knew him for his "effervescent personality, his interest and ability in absolutely everything, and his unbounded energy. . . . We live as if we will live forever; John lived as if it *was* forever," wrote Charles Freeman, '80, in *The Tech*.

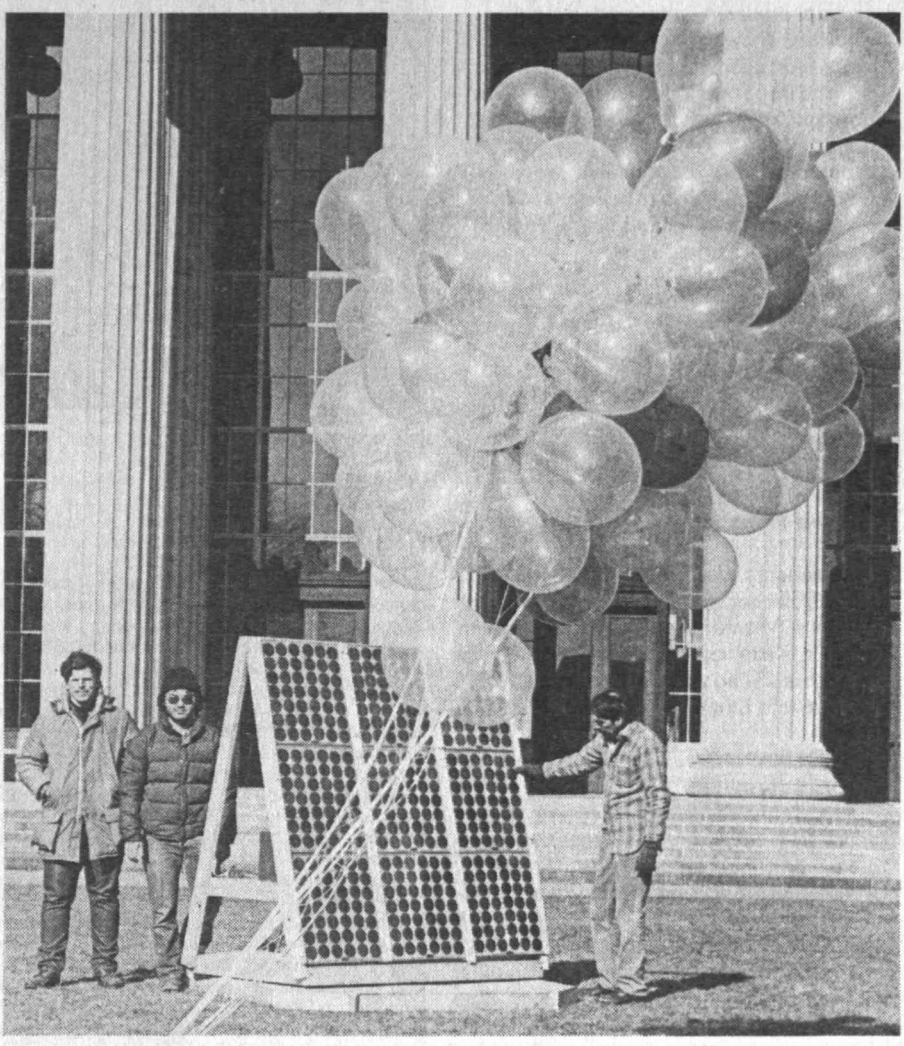
Charles H. Norris, Jr., 1910-1979

Charles H. Norris, Ph.D.'42, who was a member of the civil engineering faculty for 20 years after completing his doctorate, died on December 4, 1979, in San Diego.

Professor Norris was executive officer of the M.I.T. Department of Civil Engineering and head of its Structural Engineering Division when he resigned in 1962 to become chairman of the Civil Engineering Department at the University of Washington; three years later he became dean of engineering there, a position which he held until retirement in 1973.

Professor Norris was a specialist in theoretical structural analysis, the author of several books and a number of technical papers on structural and experimental stress analysis.

Courses



It was a cold spring day, but the array of photovoltaic panels provided by Lincoln Laboratory generated more than enough energy to fill the Killian Court to overflowing with the Beatles' sound. It was a special demonstration organized by Louis L. Bucciarelli, Jr. (right), Ph.D.'66, associate professor of engineering and technology studies, five undergraduates, and one alumnus, Peter Fiekowsky, '79. In the picture are Adam Zilinskas (left), '83, and Roy Iwatake, '83. (Photo: Calvin Campbell)

I
Civil Engineering

Antoine E. Naaman, Ph.D.'72, associate professor at the University of Illinois, Chicago Circle, has won the Martin P. Korn Award of the Prestressed Concrete Institute for best paper of the year in the *PCI Journal*, entitled "Serviceability Based Design of Partially Prestressed Beams." . . . **James Kachadorian,** S.M.'62, is currently president of Green Mountain Homes of Royalton, Vt., specializing in custom-designed solar-heated homes.

S. Bruce Smart, Jr., S.M.'47, has been elected to Board of Directors of the Celenese Corp., New York, N.Y. . . . **Edward G. Herb,** S.M.'36, passed away on January 10, 1980.

II
Mechanical Engineering

Louis F. Coffin, Jr., Sc.D.'49, a mechanical engineer at the General Electric Research and Development Center, Schenectady, N.Y., has been selected to receive the Albert Sauveur Achievement Award by the American Society for Metals, for "pioneering metallurgical achievements, which have stimulated organized work along similar lines to such an extent that a marked basic advance has been made in metallurgical knowledge." . . . **Philip M. Blair,** S.M.'50, died on November 28, 1979. He had been with the Department of Mechanical Engineering at San Jose State University, Calif., since 1957.

Karl N. Reid, Jr., Sc.D.'64, professor and head of Oklahoma State University's School of Mechanical and Aerospace Engineering, was named "Executive of the Year" by the Stillwater Chapter of the National Secretaries Association, Stillwater, Okla. . . . **Asuquo Uko,** S.M.'79, joined Bell Laboratories, North Andover, Mass., as a member of Technical Staff; he will be responsible for development on non-destructive testing means to detect ferrite — adhesive defects.

Louis F. Coffin, Jr.

III
Materials Science and Engineering

Margaret MacVicar, Sc.D.'65, has recently completed a two-week lecture tour in England with content matter focusing on the Undergraduate Research Opportunities Program at M.I.T. . . . **Robert G. Block,** S.M.'69, is presently manager, New Products Development, Technical Products Division, of Corning Glass Works, Corning, N.Y. . . . **Ernest L. Hall,** Ph.D.'77, has joined the Genereal Electric Research and Development Center Schenectady, N.Y., as a metallurgist. . . . **Theodore B. Winkler,** Sc.D.'48, has retired as assistant vice-president in Bethlehem Steel Corp.'s Research Department, after 38 years of company service.

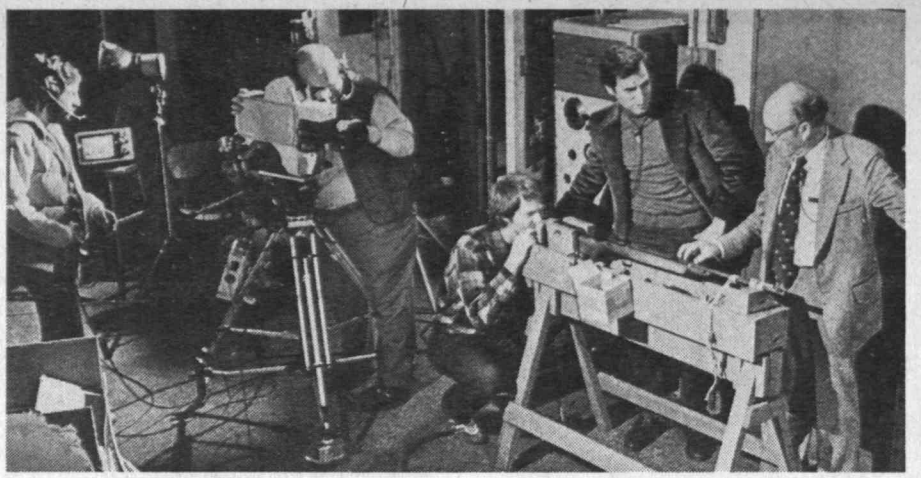
IV
Architecture

David Parry, S.M.'79, has been appointed assistant professor of drama in the Film Studies Program at Dartmouth University and director of the Dartmouth Film Society. . . . **Ann Middleton Kidwell,** S.M.'72, has been promoted to vice president and architect of the Westchase Corp., Houston, Tex., responsible for approval of all building and landscape architectural design.

V
Chemistry

Charles V. Berney, S.M.'54, a senior research scientist in the Department of Nuclear Engineering at M.I.T., has been elected to a two-year term on the executive committee that will operate in behalf of scientists using the National Center for Small-Angle Scattering Research at the Oak Ridge National Laboratory, Oak Ridge, Tenn. . . . **Carlos L. Vila,** S.M.'78, reports that he has joined the Upjohn Manufacturing Co. in Barceloneta,

Pandemonium in electrical engineering —but nothing really unusual, after all. The apparent confusion occurred when the Good Day! show (Channel 5, Boston) came to visit Professor Harold E. Edgerton, Sc.D. '31, in "Strobe Alley" late last year. "Doc" Edgerton (right) was interviewed by Peter Kouner while Christopher E. Johnson, '80, prepared to fire a bullet whose progress would be "stopped" by the high-speed camera which was waiting in the wings. (Photo: Calvin Campbell)



Lettvin at 60: a Celebration with Flip-Flops and Quincunxes

The sponsors called it a "Lettvin Fest," while Professor Jerome Y. Lettvin himself called it a "memorial service. . . . like carrying on a wake for a vampire because the subject was dead when I tackled it 30 years ago," he told Stephanie Pollack, '82, of *The Tech*.

For his 60th birthday, friends of Professor Lettvin assembled from throughout the country in mid-February to present serious (and some not-so-serious) papers in neurology and neurophysiology. Professor Lettvin himself said he tried to use the occasion to "apologize for misleading those who were my students." But Ms. Pollack concluded from the program that "not all of those students minded being misled." One of their papers was entitled "A Wrong but Interesting Lettvin Model." Others included "Flip-Flops in the Brain," "A Quincunx of Quincuxes," and "Olfactory Detection: Mother Nature at Her Conservative Best."

For Professor Lettvin the day was full of memories "of the good old days when we didn't know anything and suspected there was something to know."

Puerto Rico, working in research and development in the Control Division, after doing one year of postdoctoral work at Pennsylvania State University.

Kurt Pollak, Ph.D.'60, notes that "after fifteen years with Exxon Research and Engineering Co., have accepted a position with Wells Scientific Recruiting, Inc., Princeton, N.J., as director, Petrochemical Group. . . . **William S. Benedict,** S.M.'33, an authority on spectoscopy who was professor emeritus of the University of Maryland, passed away January 10, 1980. . . . **Lofti A. Zadeh,** S.M.'46, has been elected as a fellow of AAAS for research into the theory of fuzzy sets and its applications to artificial intelligence, linguistics, logic, decision analysis, and methods of analyses of humanistic systems.

Scott H. Foster, S.M.'34, of Mattapoisett, Mass., died August 28, 1979. . . . **Horia I. Metiu,** Ph.D.'74, has received several contracts at the University of California, Santa Barbara, to aid in continuing research projects in the development of better catalysts for industry. . . . **William H. Rastetter,** S.M.'71, has been awarded a two-year basic research fellowship by the Alfred P. Sloan Foundation.

VI
Electrical Engineering and Computer Science

Gordon T. Gould, Jr., S.M.'50, retired lieutenant general in the U.S. Air Force and former director of the Defense Communication Agency, died August 7, 1979. . . . **Kenneth W. Exworthy,** S.M.'59, reports, "I started work last fall as senior project engineer in a new electronic division at the Ansul Co." . . . **Kenneth E. McVicar,** S.M.'50, has been named vice-president and general manager of the Command, Control and Communications Division of the Mitre Corp., Bedford, Mass.

Jack Hillibrand, Sc.D.'56, staff technical advisor, engineering, for RCA's Government Systems Division, Cherry Hill, N.J., has been elected a fellow of the Institute of Electrical and Electronics Engineering for his "contributions to the development of integrated circuits." . . . **Gordon Harris, Jr.,** S.M.'66, has joined the staff at Lawrence Institute of Technology as a lecturer in the School for Associate Studies. . . . **Daniel E. Noble,** S.M.'38, former vice chairman and director emeritus of Motorola, Inc., died February 16, 1980. He was an "internationally-known scientist and engineer who helped pioneer modern FM two-way radio communications and was one of the early leaders in solid state electronics technology."

Avery Hevesh, S.M.'63, is currently principal staff engineer in the Reliability Engineering Department of the Raytheon Equipment Development Laboratories. . . . **Stephen J. Fricker,** Sc.D.'50, is presently a surgeon at the Massachusetts Eye and Ear Infirmary, director of pediatric ophthalmology, and associate professor of ophthalmology at Harvard Medical School. . . . **Gary J. Handler,** S.M.'66, is presently supervisor of the Electronic Tandem Network (ETN) Planning Group at Bell Laboratories, Holmdel, N.J. . . . **John Makhoul,** Ph.D.'70, is a 1980 Fellow of the Institute of Electrical and Electronics Engineers for his contributions "to the theory of linear prediction and its applications to spectral estimation, speech analysis, and data compression." . . . **Virgil Cox,** S.M.'62, is presently an assistant professor at Maine Maritime Academy, Castine, Me.

VIII
Physics

Herman Feshbach, Ph.D.'42, Cecil and Ida Green Professor of Physics at M.I.T., has assumed the post of president of the American Physical Society for the 1980 term. . . . **Jerome W. Riese,** Ph.D.'58, has been appointed as research associate at the Kimberly-Clark Corp., Neenah, Wis. . . . **David J. Rose,** Ph.D.'50, has been named to the Board of Directors of the Scientists' Institute for Public Information.

Richard J. Cohen, Ph.D.'76, assistant professor of physics and of health sciences and technology, has been appointed Helmholtz Assistant Professor of Health Sciences and Technology.

W. Murray Bullis, Ph.D.'56, was awarded a silver medal by the Department of Commerce's National Bureau of Standards "for outstanding leadership of a major program for developing innovative measurement technology for integrated circuits." . . . **Avraham Tuchman,** Ph.D.'64, has been named section chief of the Electro-Optical Sensor Design Section in the Electronic Systems Directorate of Avco Systems Division, Wilmington, Mass.

Cyril M. Harris, Ph.D.'45, professor of architecture and engineering at Columbia University, has been awarded an American Institute of Architects 1980 medal as "an individual who has inspired and influenced the architectural profession." . . . **Dayton H. Clewell,** Ph.D.'33, has retired as senior vice-president of Mobil Oil Corp., where he concentrated on petroleum research, geophysics and oceanography. . . . **Nathan S. Wall,** Ph.D.'54, a former M.I.T. faculty and staff member who was professor of physics at the University of Maryland, died September 2, 1979.

X
Chemical Engineering

Clyde K. Smith, S.M.'35, reports that he has retired from Bechtel, Inc., and is engaged in volunteer activities in natural and biological sciences at California Academy of Sciences in San Francisco. . . . **Hugh D. Sims,** S.M.'33, of Lewisburg, Pa., died on January 18, 1980. . . . **Richard K. Lester** has been appointed Esther and Harold E. Edgerton assistant professor in the Department of Nuclear Engineering at M.I.T. for two years.

Daniel S. Maisel, Sc.D.'47, senior planning advisor for Exxon Chemical Co., Florham Park, N.J., has been named chairman of the Government Programs Steering Committee of the American Institute of Chemical Engineers. . . . **Frederick J. Port, Jr.,** S.M.'40, of Philadelphia, Pa., died in July, 1978. . . . **Maurice F. Granville,** S.M.'39, will retire in November from the position of chairman and chief executive officer of Texaco, Inc. . . . **David Fulton,** S.M.'37, has joined the Lummus Co. as director of business development.

W. Kenneth Davis, S.M.'42, vice-president of Bechtel Power Corp., San Francisco, Calif., has been elected vice-president of the American Institute of Chemical Engineers. . . . **George C. Porter,** S.M.'66, has been promoted from vice president and general manager to president of Envirotech Corp., Dohrmann Division, Santa Clara, Calif.

James S. Law, S.M.'72, reports the birth of his second son, Charles Douglas Law. . . . **Kris I. Kudrnac,** S.M.'74, notes that she is working as marketing engineer for U.S. Operations of Anachemia Chemicals, Inc. . . . **Walter C. Benzing,** S.M.'48, is the recipient of the Semmy Award of the Semiconductor Equipment and Materials Institute for outstanding contributions to the

Planning for Feedstocks In the Next Energy Crunch

Aromatics from petrochemical feedstocks are the lifeblood of plastics and synthetic fibers — and also of lead-free gas. They're in short supply, with prices up nearly 100 per cent in the last year. And supplies may well be even shorter in the future — an uncertainty which could have "a large impact on the future growth of the economy," says Roy N. Levitch, Sc.D. '66, economic support manager for Shell Oil Co.

For the Department of Energy has now withdrawn from petrochemical feedstocks the priority position which was given them in the energy stand-by allocation system established during the 1973-74 crude oil embargo. The earlier system assured users of gas/oil feedstocks and naptha 100 per cent of their requirements. As of this fall, petrochemical feedstocks will instead be allocated in a future emergency in the same way as fuels — a fraction of prior years' use.

That means that feedstocks — already in short supply — will simply be unavailable in any future "energy crunch," Dr. Levitch told members of the American Chemical Society at their annual fall meeting in Washington, D.C. For several reasons, said Dr. Levitch, that's bad news:

☐ Feedstocks and the aromatics which come from them are basic ingredients for many industries. Shortages of feedstocks wil proliferate into countless other industries in terms of unfilled orders, layoffs, lower profits, and uncertainties. Indeed, one barrel of oil turned into feedstocks may be the raw material for $200 worth of finished products. Petrochemicals provide 29 million jobs in the U.S.

☐ Uncertainty about future feedstock supplies could have "a very negative effect on the willingness of petrochemical suppliers to invest capital in new plants."

☐ Products which depend on petrochemical feedstocks are among major U.S. exports, and it is "clearly in the best economic interest of the U.S." that they remain so. This is becaue of "the tremendous increase in value the petrochemical industry creates by transforming oil and gas into products worth many times the costs of the oil and gas from which they come," Dr. Levitch explained. "Only about 120,000 barrels of hydrocarbons per day are used to create a favorable trade balance of over $5 billion per year. . . . As a maturing nation, (we) need to be much more export-minded to balance out our increasing dependence on imported raw materials."

"Petrochemical feedstocks should rank high among essential petroleum uses in our country," Dr. Levitch described; shortages of feedstocks (they represent but 4 per cent of U.S. petroleum consumption) should not be allowed to limit economic growth. "The industry should continue to receive priority status."

semiconductor industry in epitaxial silicon deposition.

Bernard Chertow, Sc.D.'48, has been elected vice-president of manufacturing for the worldwide Industrial Division of Bristol Myers Co. . . . **William K. Overturf,** S.M.'40, of Manhattan Beach, Calif., died on September 26, 1979. . . . **Stephen H. Baum,** S.M.'64, has been elected president of Diamond West Energy Corp., Salt Lake City, Utah.

XI

Urban Studies and Planning

Richard Conway, S.M.'57, reports that he has just coauthored a book, *Handbook of Industrial Waste Disposal*, published by Van Nostrand Reinhold Co., January, 1980. . . . **Leonard M. Henny,** S.M.'66, is currently heading the Media Studies Program of the Center for International Development Education, Sociological Institute, University of Utrecht, Holland.

Hans Bleiker, Ph.D.'72, reports, "My wife Annemarie and I have developed an antidote to the Proposition 13 mood that is sweeping the country. We call it 'Proposition 31' and is based on research we were involved in at M.I.T.'s Urban Systems Laboratory in the late 1960s and early 1970s. We have formed IPP (Institute for Participatory Planning) and are training public officials across the country in it." . . . **Donna D. Berman,** Sc.D.'72, has been elected as a corporator of the Charlestown Savings Bank, Boston, Mass. . . . **Charles F. Negele,** S.M.'62, of Bethel Park, Pa., passed away on April 12, 1977.

XII

Earth and Planetary Sciences

C. John Suen, Sc.D.'78, has rejoined the department of earth and planetary sciences at M.I.T., as a member of the research staff. . . . **Edward Andrews Colson,** S.M.'40, a retired geophysical engineer who was one of the original staff members of Ruge-DeForest, Cambridge, Mass., died November, 1978, in Manchester, N.H.

William B. Farrington, Ph.D.'53, reports, "After being single from 1955 to 1979 and bringing up three children — who are now married and with their spouses have a total of 13 college degrees — it was my turn and I married Ms. Trudy E. Eby on January 3, 1979." . . . **William Walsh,** Ph.D.'54, with credentials in water location and protection, is a candidate for a water district commissioner's post, in Acton, Mass. . . . **Charles M. Swift,** Ph.D.'67, has been promoted to division geophysicist, Geothermal Exploration Division of Chevron Resources Co., Standard Oil Co. of California.

XIII

Ocean Engineering

Peter T. Tarpgaard, Ph.D.'68, reports, "I have recently accepted a position as principal analyst, National Security and International Affairs with the Congressional Budget Office, an agency of the Congress." . . . **Edward S. Carmick,** S.M.'40, notes that he has fully retired and is presently engaged in technical reading of tapes for the blind. . . . **Nancy Spinka Timmerman,** S.M.'74, of Bolt Beranek and Newman, Inc., Cambridge, Mass., has become the first woman to be admitted to full membership in the Institute of Noise Control Engineering. . . . **Charles E. Columbus,** S.M.'43, a retired Purdue University Calumet faculty member who had recently been inducted into the Coast Guard Academy Athletic Hall of Fame, passed away on January 18, 1980. . . . **Judith Kildow,** associate professor of the Department of Ocean Engineering at M.I.T., has recently edited a book entitled *Deepsea Mining*, which "examines whether United States policies reflect accurately the strategic and economic value of the man-

ganese nodules that cover much of the sea floor and whether the political and economic risks of accelerated development are warranted."

XV

Management

Erskine N. White, Jr., S.M.'49, executive vice-president, corporate affairs, Textron Inc., has been appointed chairman of the 28th annual Brotherhood Award Dinner for the National Conference of Christians and Jews. . . . **Robert P. Clagett,** S.M.'67, is currently general manager of Western Electric Engineering Research Center, Princeton, N.J. . . . **F. John Long,** S.M.'66, reports that he recently published a series of papers entitled, "Some Ethical Considerations Concerning Individual and Institutional Powers and Responsibility."

James M. Utterback, Ph.D.'69, professor in the School of Engineering at M.I.T., has been appointed acting director of the Center of Policy Alternatives during the absence of Professor J. Herbert Hollomon '40. . . . **Larry L. Schedin,** S.M.'76, reports, "I have started a new energy consulting business in Minneapolis, Minn. My experiences with large corporations such as Pillsbury, Cargill, and General Mills indicated that businesses need a new approach to energy planning that goes beyond the band-aid fixes found in most conservation programs." . . . **Paul J. Puzzanghera,** S.M.'79, has been appointed a consultant in the Planning Division of Management Decisions Systems, Inc., Waltham, Mass.

Ollie J. Akel, S.M.'67, is currently vice president, Exxon Middle East Industries, Inc., Saudia Arabia. . . . **Donald H. Swartz II,** S.M.'74, recently formed a retail store to serve local markets in areas of gourmet cookware, dinnerware, bathware and other consumer designer products. . . . **Jonathan J. Golovin,** Ph.D.'75, has started a consulting firm, Consilium Associates, Inc., specializing in management consulting service for the semiconductor industry. . . . **Richard B. Gillett,** S.M.'52, has been promoted from general sales manager to director, business development, at RJR Archer, Winston-Salem, N.C.

Oliver C. Boileau, S.M.'64, is currently president of General Dynamics, Norwich, Conn. . . . **John R. Dallepezze,** S.M.'67, is currently business manager, Lighting Products, Electrical Products Division at Corning Glass Works, Corning, N.Y. . . . **Eugene C. Kalkman,** S.M.'61, "was one of ten Air Force military and civilians throughout the country who recently received a Distinguished Equal Employment Opportunity Award." . . . **Richard F. Armitage,** S.M.'59, of Warren, Oh., died in July, 1977. . . . **John J. Lenahan,** S.M.'68, is currently group president of Delaware North Companies, Inc., Buffalo, N.Y., responsible for the firm's general business subsidiaries.

John M. Wynne, S.M.'56, has left his position as vice-president, adminstration and personnel, at M.I.T. to join his wife in the management of her business, after 22 years of service at the Institute. . . . **E. Quinton Gordon,** S.M.'77, has been appointed to the position of manager, business planning for the North American Operations of International Harvester's Agricultural Equipment Corp., Chicago, Ill. . . . **Laurence C. Baker,** S.M.'75, has joined the corporate staff of Colt Industries as assistant treasurer and director of investor relations, New York, N.Y.

E. Quinton Gordon

Mark J. Deck, S.M.'79, has been appointed as a management scientist in the Consumer Research Division at Management Decision Systems, Inc., Waltham, Mass. . . . **Philip H. Funk,** S.M.'67, has been named vice president of corporate systems at the New Hampshire-Vermont Blue Cross and Blue Shield, Barre, Vt.

XVI

Aeronautics and Astronautics

Paul Basile, S.M.'72, is currently a research analyst for the Subcommittee on Energy and Power, United States House of Representatives. . . . **Gerd Hengsbach,** S.M.'74, notes that he is assistant to the managing director and corporate vice president of Commercial Aircraft Division Messerschmitt-Bolkow-Blohm, West Germany. . . . **Louis H. Benzing,** S.M.'52, resigned as president and chief executive officer of the Decision Data Corp. to pursue personal business interests. . . . **William M. Harnish,** S.M.'51, of Lafayette, Calif., passed away in September, 1979. . . . **Kenneth B. Morton,** S.M.'74, has been elected vice president of INA Diversified Services, Inc., Philadelphia, Penn.

XIX

Meteorology

Clifford A. Spohn, Sc.D.'48, is currently deputy director of the National Environmental Satellite Service, recently designated by the President to manage all civil remote sensing operational programs of the United States. . . . **Jule G. Charney,** Alfred P. Sloan Professor of Meteorology, has been honored by two scientific groups. He was elected an honorary fellow of the Indian Academy of Sciences and awarded the Cleveland Abbe Award of the American Meteorological Society.

XX

Nutrition and Food Sciences

George L. Blackburn, Ph.D.'73, is currrently associate professor of surgery and director of the Nutrition Laboratory at the New England Deaconess Hospital, Boston, Mass. . . . **Arthur E. Humphrey,** S.M.'60, of the University of Pennsylvania, has been named to the National Academy of Engineering Task Force on Engineering Education to "define potential problems, set forth questions that need to be asked about engineers' roles and responsibilities in society."

XXII

Nuclear Engineering

James D. Levine, Ph.D.'63, has relocated to Dallas, Tex., to become manager of Solar/Energy Systems at Texas Instruments, Inc. Previously, he was located — for sixteen years — at RCA Research Laboratories, Princeton, N.J. . . . **Jerry A. Sovka,** Sc.D.'66, is the site engineering manager of the Wolsung-I nuclear power plant, a 600-MWe reactor being built for Korea Electric Co., South Korea. . . . **Daniel R. Raichel,** S.M.'58, has been appointed director of acoustics and noise control at Marland Bartholomew and Associates, Inc., St. Louis, Mo.

George I. Kachen, S.M.'65, has been named marketing manager for laser research and development at Avco Everett Research Laboratory, Inc. . . . **Mark H. Magnussen,** S.M.'67, has retired from the Army and become vice president and general manager of Femior, a northern Virginia building maintenance management firm. . . . **John M. Reade,** S.M.'69, has been appointed to the newly created position of director of commercial development for the Arcair Co., a wholly-owned

subsidiary of Air Products and Chemicals, Inc.

Technology and Policy Program

Bob Chen, recently participated in developing a draft plan of action for the World Impact Studies Program at the United Nations Environment Programme in Nairobi, Kenya. He is currently working at the Climate Research Board, Washington, D.C. . . . **Tom Davidson,** upon returning from a brief sojourn in Europe, is working for United States Windpower, Burlington, Mass., which manufactures windmills capable of generating up to 50 kilowatts of power. He will be installing, testing and improving wind machines this summer on Cape Cod.

David Hanrahan, whose article, "Hazardous Wastes: Current Problems and Near-Term Solutions," appeared in a recent issue of *Technology Review*, recently moved to Melbourne, Australia, with Binnie and Partners Consulting Engineers to work on problems of water supply. . . . **Rick Hornby,** has been working on the preparation and implementation of an energy plan for Nova Scotia while employed by the Nova Scotia Research Foundation Corp. The plan is the first effort of the province to take a comprehensive look at its energy problems, incorporating the opinions of public interest groups, as well as provincial and federal government.

Treating Water in China: a New Opportunity for the West

With over 700 million, China is the most populous nation in the world. But only 5 percent of its wastewater undergoes any sort of sewage treatment.

"The Chinese need our help badly," concludes Ross McKinney, S.M.'49, Veatch Distinguished Professor of Environmental Engineering at the University of Kansas, after a five-week teaching and inspection assignment at T'unghi University, Shanghai, late last year.

Most Chinese wastewater, both domestic and industrial, "is simply let loose in the fields and streams . . . They have a long way to go with their environment," Professor McKinney says. But he is convinced from his visit alone that the Chinese want to solve their waste problems, and he thinks the U.S. has a lot of the technology they need.

Professor McKinney found the Chinese familiar with wastewater management techniques as of the early 1960s, but later work was largely unknown to them. So his assignment, as one of the first group of U.S. scholars and scientific experts to visit under an international agreement signed a year ago, was to bring a few experts up to date.

There were morning lectures to practicing engineers and T'unghi faculy members and afternoon seminars and student conferences. Half of those in his classes spoke English, and an interpretor was always available.

But progress will come slowly, says Professor McKinney. "There are a large working class and a class of highly skilled people. But there are few in between to actually put technology to work."

How Eli Shapiro Tested His Decisionmaking and Explains His "Weakening" Sense of Optimism

Economics has never been work for Eli Shapiro, Alfred P. Sloan Professor of Management at M.I.T. "It was always a pleasure, and that's very helpful in whatever you choose as a career," he told Mark L. Bastoni in an interview for Delta Airlines' *Sky* magazine last fall.

Most of Professor Shapiro's life has been spent teaching and researching in his chosen field — first at the University of Chicago, then at M.I.T., then Harvard, now (since 1976) again at M.I.T. He likes the academic life — and that of a consultant, to which he's devoted a good many days — "many different firms . . . with very different problems."

"You have much more independence, more time to contemplate, and much more time to study." And you "don't have to make a decision, (and) you don't have to implement it, either."

But finally in the late 1960s this apparently idyllic irresponsibility began to gnaw at Professor Shapiro: there was "a fragment of something lacking" in his career, he told Mr. Bastoni. "I was sort of curious to see whether I could, in fact, make a decision, live with it, and sleep at night." So when the Travelers Insurance Co. asked him to be chairman of its Finance Committee in 1971, to manage the portfolio, his answer came quickly enough.

The first half of the 1970s was a hard period, with the financial markets "in various stages of disarray. . . . It was either the bond market that was going to pot, or the stock market . . ." Yet in 1976 Professor Shapiro emerged unscathed, having satisfied himself that he could manage a line position. "I don't mean to suggest that I didn't make any mistakes," he told Mr. Bastoni. "There's no businessman worth his salt who doesn't make mistakes." But Professor Shapiro was ready to return to the more contemplative posture of the academic. Now his principal teaching responsibility is a course in financial management for the Sloan Fellows, an intensive presentation of a subject in which the instructor has some very practical as well as academic qualifications.

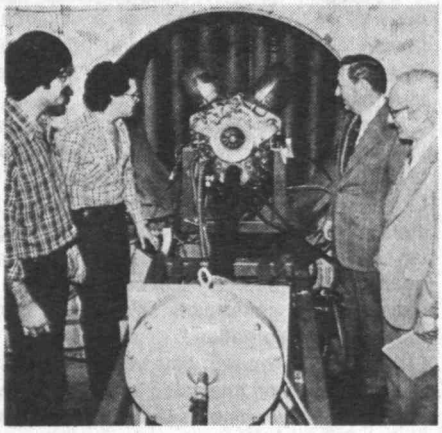
A Weakening Sense of Optimism

Professor Shapiro has always had a buoyant sense of optimism about the U.S. economy and the potential America has for problem-solving and production. But he thinks that sense is weakening now. Maybe, he muses, that's because he's growing older; but he doesn't think so. He worries about the growing power of uncompromising single interest groups, the difficulty of leadership in the nation.

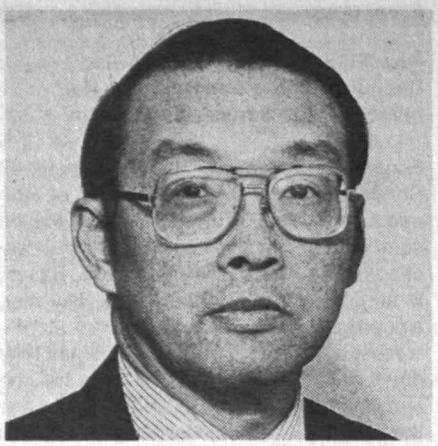
Consider, for example, he says, President Carter's effort to mobilize concern for our energy problems as "the moral equivalent of war." People don't respond; they see the energy situation as "just awfully annoying. At worst, all it means is that people have to stand in line for gasoline." And whenever oil prices rise and the increase is passed on to the consumers, the oil companies are "immediately beset as thieves," threatened with price controls or government takeovers. Under these conditions prospects for profitable future investments in energy look dim, and some oil companies are beginning to "diversify out of the energy field entirely."

Professor Shapiro thinks back to his first years of studying in the 1930s: for President Franklin D. Roosevelt, being a leader was easier. "When the banks closed in 1933, about a quarter of the labor force of the U.S. was unemployed. (Roosevelt had) no opposition, because everybody was so desolate and desperate."

Part of Mr. Carter's problem — though Professor Shapiro wouldn't really want it otherwise — is that "people are well fed, well clothed, and well housed."



The object of everyone's admiration is a General Motors C-18 gas turbine engine, a gift from GM's Detroit Allison Division to the Department of Aeronautics and Astronautics. Joseph Padavano, '80 (left), and Fred E. Shecter, '80, students in the department's Undergraduate Projects Laboratory, went to work on a performance evaluation of the engine even while Donald J. Atwood, '48, vice president and general manager of the division, and Professor Jack H. Kerrebrock (right), head of the department, were still carrying out the official dedication. (Photo: Calvin Campbell)



J. W. Mar

Hunsaker Professorship to Mar

To recognize his contributions to teaching programs in the Department of Aeronautics and Astronautics, James W. Mar, '41, has been named the Jerome C. Hunsaker Professor of Aerospace Education.

Professor Mar founded the department's Laboratory for Advanced Composites, and he's a co-founder of the Space Systems Laboratory, and he was an early enthusiast for the department's unified engineering subject which introduces undergraduates to the scope of aerospace engineering. He's chairman of the School of Engineering's Committee on Engineering Education and of the Athletic Board, and he has an extensive record of service to the aerospace profession outside M.I.T.

How Physicists Went Public for the Pacific Northwest's Eclipse

The physicists decided that the total eclipse a year ago in the Pacific Northwest was "really rather simple and nothing to get excited about." But two of their Montana State University colleagues, Lynda and Michael Sexson of the Departments of Religion and English, respectively, saw it differently.

Any reading of history, they said, shows that an eclipse has the potential to excite people.

And the physicists' experience proved the rightness of that prediction.

Our telephones "rang constantly," writes Professor **Larry D. Kirkpatrick,** Ph.D.'68, in *The Physics Teacher* (October, 1979). There were press interviews, radio and television appearances, speeches to Lions Clubs and all other kinds of community forums, lectures at schools — you name it, they did it.

Afterwards, when they finally "came down from our 'eclipse high,' " Professor Kirkpatrick and his colleagues decided that "the effort was worth it. . . . There were many rewards," he and Professor Gerald F. Wheeler (now of Temple University) write in *The Physics Teacher* — "the reward of taking part in the celebration, of feeling that people got something from our efforts, of sharing the physics world view with people from different disciplines."

Here is some advice from Professors Wheeler and Kirkpatrick on the basis of their "Eclipse '79 Celebration" experiences:

☐ *Know your audience and your assignment.* "Being willing to talk about something isn't the only requirement for success. Get a general description of the expected audience and the constraints so that you can tailor your presentation."

☐ *Find out how much time you'll have.* On several radio and television interviews they were given "five minutes to tell all we knew about the event." Speeches at schools are longer — the most latitude. But the time constraint on an after-lunch or after-dinner speech means "you'll probably only be able to highlight certain aspects of your topic."

☐ *Try to take control of your situation.* That advice is especially appropriate for radio and television interviews, where "the interviewer has most of the control over the direction of the conversation." To influence it, suggest Drs. Wheeler and Kirkpatrick, try to discuss with your interviewer what you think should be covered before the interview goes on the air.

☐ *Be well prepared.* Especially on radio and television, you cannot "grope for the right words or phrases to explain in fine detail. That pause for emphasis that all of us make in class is called 'dead time' on radio and television, and it's a 'no-no'."

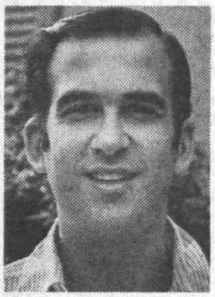
☐ *Keep it simple.* "Talking about physics is an exercise in translation," write Professors Wheeler and Kirkpatrick. "The translator must take the logic, the vocabulary, and even the feelings of physics and communicate them in an entirely different language . . . while maintaining the highest possible fidelity. Maintaining fidelity is a tricky business . . . one must search creatively for ways to translate as much as possible."

☐ *Use audio-visuals.* But remember that "most printed or typed material simply cannot be read from the back row." And preparations should begin "early enough to allow time for failures."

Recalling their experiences, Professors Wheeler and Kirkpatrick hypothesize that "the general public seems to have a split personality with science. People are fascinated with the words of science — black holes, lasers, photons, and so on," they write. But they're also scared away by those same words, because most people "feel uncertain about their ability to understand scientific topics," however well presented.

Puzzle Corner
Allan J. Gottlieb

How to Play "Queen Bee"



Allan Gottlieb is associate professor of mathematics at York College of the City University of New York; he studied mathematics at M.I.T. (S.B. 1967) and Brandeis (A.M. 1968, Ph.D. 1973). Send problems, solutions, and comments to him at the Department of Mathematics, York College, Jamaica, N.Y. 11451.

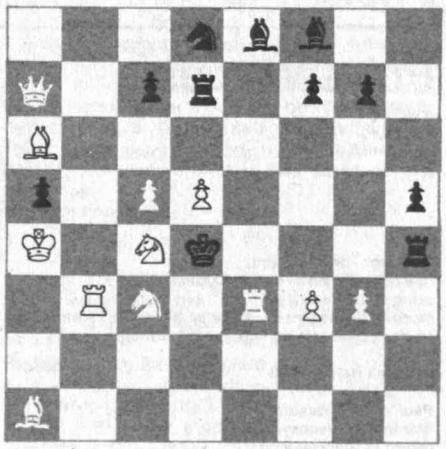
Late in January I fell while running, and 30 stitches were needed to close the wound near my right knee. Fortunately, my wife Alice was with me, brought me to the emergency room, and was very helpful during recuperation; I was fully recovered by mid-February, and now I appreciate the convenience of being able to get around freely. Although I don't recommend using crutches and wearing a Jordan splint, the experience has at least taught me how hard it must be for the physically handicapped. And it is a pleasure to report that many New Yorkers gave me their seats on buses and subways.

Enough of that, and on to the problems.

Problems

NS 19 We begin with a past problem, originally submitted by Richard Orr and published as **1979 D/J 5,** that was never (completely) solved: A game is played by N players where the loser doubles the money of the other N — 1 players. After N games, each player has lost once and each has D dollars. Find d_i, the number of dollars the ith player began with.

MAY 1 Our first new offering is a chess problem from John Cronin: given the situation shown, White to play and win.



MAY 2 Moving from chess to number theory, we present a problem from Harry Zaremba: The following two series have sums with a common characteristic for any number of terms n:

$S_1 = [(m + 1)m/2]^\alpha + (m + m^2)^3 + (m + 2m^2)^3 + (m + 3m^2)^3 + \ldots$

$S_2 = [(m + 1)m/2]^2 + (N_2N_3)^3 + (N_3N_4)^3 + (N_4N_5)^3 + \ldots$

The first term in each series is the sum of the cubes of the initial m positive integers, and the N in S_2 are integers defined as follows:

$N_1 = 1$; $N_2 = m$; $N_{i+2} = N_{i+1} + N_i$ $(i = 1, 2, 3, \ldots)$

for any positive integers $m = 1, 2, 3, \ldots$. The recursive definition of the numbers N generates Fibonacci numbers when $m = 1$. Find the general expression for the sum of each series and determine the common characteristic of the sums of the series for any m and n.

MAY 3 Now a word problem from Frank Rubin. For each $N < 10$, find the shortest possible English word containing n syllables. Do not use proper names, abbreviations, or initials.

MAY 4 Doug Spizer has a game designed for very busy people; he calls it "Queen Bee." It is played by N people $(N > 2)$ who wager a sum A of money in the following manner. Initially the entire group owes the amount A to an outside party, and each person's expected payout is A/N. Each person flips an unbiased coin, and if there is an "odd man out" that person becomes the "queen bee." If there is no "odd man out" on any particular flip, all players flip again until a "queen bee" is chosen.

The "queen bee," when determined, is committed to paying the amount A to the outside party but has the opportunity to win that same amount back from *each* of the other players by means of a single (unbiased) coin toss by each other player.

1. What is the probability of determining a "queen bee" on each of the group tosses?
2. What is the expected number of tosses required to obtain a "queen bee" for three players? Four players? N players?
3. What is the expected payout for each player, prior to the toss for determination of the "queen bee"?
4. After determination of the "queen bee," what is the net expected gain or loss for each player? (i.e.; for "queen bee" and for others).
5. Should the "queen bee" be considered a "winner" or a "loser" at the time he [an inappropriate pronoun — ed.] is chosen?

MAY 5 Our last regular problem is from Richard King:

A message switch is a computer hardware/software system that allows messages to come via input lines, stores them, and sends them out on one of many output lines, choosing the time of output and the output line according to programmed criteria. Consider the following simple but large message switch, which has a very large number of input lines and an infinite number of output lines. The output lines are numbered L_1, L_2, etc. Messages come into the system at random, Poisson distributed, with a mean frequency of two per minute. Any message that comes in is immediately output on the lowest-numbered non-busy output line. This immediately makes that output line busy, and it remains busy for one minute, after which it is non-busy until a new message is output on it. The question is: What is the "duty cycle" (percentage of the time the line is busy) of each line L_i, given i? Note that the obvious answer based on the Poisson distribution is wrong. If N messages have been input in the last minute, N output

lines will be busy; but they won't necessarily be the first N, because at the time one of these N messages finished coming in all of the first N lines might have been busy with previous messages, forcing this message "up" to a higher numbered line.

Speed Dept.

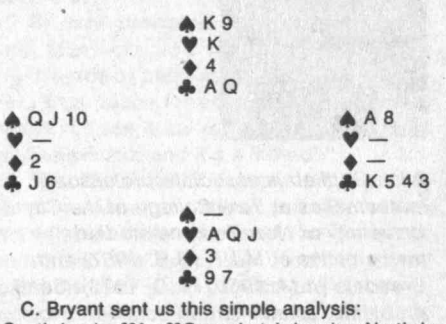
MAY SD 1 Charles Heiberg wants you to find the fallacy in the following argument: Using integration by parts with $u = (\ln x)^{-1}$; $du = -(\ln x)^{-2} \cdot dx/x$; $dv = x^{-1}\,dx$; and $v = \ln x$, one obtains:
$\int (x \ln x)^{-1}\,dx = 1 + \int (x \ln x)^{-1}\,dx$
which implies that $0 = 1$.

MAY SD 2 We close with a problem from Emmet Duffy: plot the equation
$\ln [x/(1 - x)]$
for various values of x for the range $y = 0$ to $y = 3$. (The x range will be approximately $x = 0.07$ to $x = 0.93$.) Why is the resulting graph:

1. A hell of a curve?
2. Naughty but nautical?
3. American Gothic?

Solutions

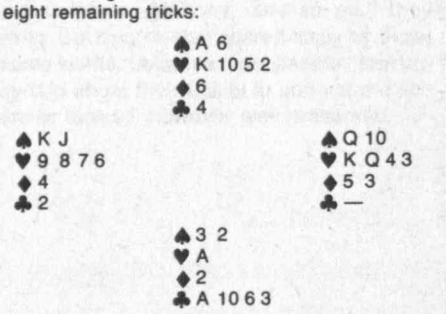
J/J 1 As modified in November. The goal is for South, on lead, to win all six remaining tricks;



C. Bryant sent us this simple analysis: South leads ♥A, ♥Q, and ♦J, leaving North in the lead with ♠K, ♠9, and ♣A and South holding ♥J, ♣9, and ♣7. If East retains only one spade (the A), North leads ♠9; South ruffs, leading to North's ♣A, and North's ♠K takes the last trick. If East retains ♠A and ♠8, and West only one club, North leads ♣A and then a spade which South ruffs; South then leads clubs for the last trick. If East retains ♠A and ♠8 and West ♣J and ♣6, North leads ♠K; if East covers with ♠A, South ruffs and leads clubs to North's ♣A, whose ♠9 is then good for the last trick; but if East does not cover the ♠K, South discards a club, North then leads ♠9 which South ruffs and leads clubs to North's ♣A for the last trick.

N. Piffenberger used a similar strategy.

D/J 1 The goal is for South, on lead, to win all eight remaining tricks:



After replacing North's ♥K with a ♥J and choosing clubs as trump, Douglas VanPatter continued as follows:
1 — ♥A.
2 — ♣3 to North's ♣4, with East throwing a diamond.
3 — ♥J carried by ♥Q and niffed with ♣6.
4 — ♣10; West and East each throw a diamond and North throws ♠6.
5 — ♦2 to North's ♦6. West is squeezed; if West throws a heart, East can throw a spade. Now pin the ♥9 by leading ♥10 from North, thus setting up ♥5 in the dummy for the last trick — assuming East covers; otherwise, ♥10 is good. If West throws a spade, East will throw a heart (he cannot throw a spade, since if he does South can cash ♥A, setting up ♠3 in South's hand; now lead ♥5 and ruff out East's ♣K, setting up ♥10 in North's hand with ♠A for reentry.

Responses were also received from Peter Ostapenko, Winslow Hartford, Richard Hess, Ronald Ort, Shirley Wilson, Edwin McMillan, James Prigoff, Harry Hazard, Avi Ornstein, Franklin Seeley, Bo Jansen, N. Piffenberger and Lawrence Felton.

D/J 2 Replace each letter by a different decimal digit to make the arithematic correct:

W H I T E x X = G R E E N
G R E E N x X = B L A C K

Everyone agrees with the following solutions:

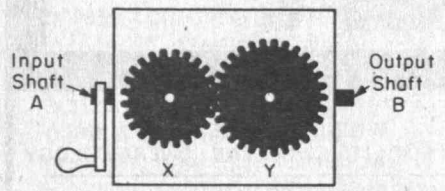
W H I T E × X = G R E E N
1 9 0 8 3 × 4 = 7 6 3 3 2
1 5 7 2 3 × 6 = 9 4 3 3 8

G R E E N × X = B L A C K
4 8 5 5 3 × 2 = 9 7 1 0 6

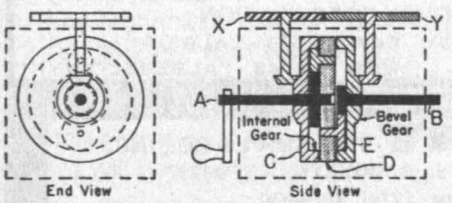
Some readers found alternate solutions with either G or W zero; but leading zeros are not usually allowed in cryptarithmetic problems.

Solutions received from Winthrop Leeds, Emmet Duffy, Avi Ornstein, Dennis Sandow, Steve Feldman, Winslow Hartford, Richard Hess, Naomi Markovitz, and Harry Hazard.

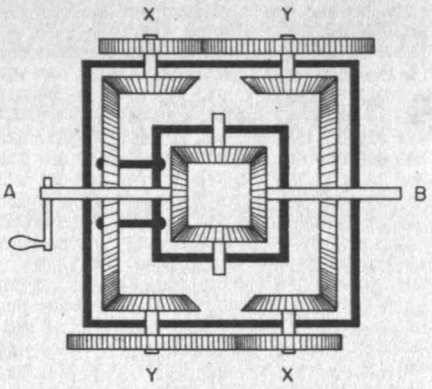
D/J 3 The diagram represents a box from which two keyed shafts project toward the reader. With gears X and Y on these shafts as shown, there is a true drive connection between input shaft A and output shaft B, but if the gears are interchanged shafts A and B can be turned independently. The box contains nothing but ordinary gears, shafts and bearings. What is the mechanism?



Claude von Roesgen suggests that the answer is two differentials. If the transmission ratios are not equal, A and B are independent. He supplied a diagram to illustrate this arrangement; but I am printing instead (below) the original published solution since it is a little clearer and I *believe* incorporates the same idea. (Note: I am *not* a mechanical engineer.) A and B are gear-ended shafts; C and E each carry internal and bevel gears; D carries two planetary idler gears. For a given set of gear ratios "inside" the box, there is *only one* ratio R for X:Y which positively *connects* A and B; a simpler device *disconnects* for one R only.



Winthrop Leeds has a method where the differential box itself rotates:



The back of the box has duplicate X and Y gears as on the front, but they are assembled as shown. All four inside bevel gears are duplicates. The two ring gears are duplicates, but the left one is riveted to the center differential gear box. Gearing locks boxes, so crank A drives shaft B in opposite rotation. If gears X and Y on the front are now interchanged, the differential gear box can rotate and shafts A and B can be turned independently, as required.

Also solved by Raphael Robertazzi, Frank Rubin, James Landau, Edwin McMillan, Richard Merrill, and Richard Hess.

D/J 4 Find the sum of the following series of terms for any positive integer m:

$S(m) = 1^3 + 2^3(1^3 + 3^3) + 3^3(1^3 + 3^3 + 5^3) + \ldots$
$\ldots + m^3[1^3 + 3^3 + 5^3 + \ldots + (2m-1)^3]$; or

$$S(m) = \sum_{n=1}^{m} n^3\left[\sum_{i=1}^{n} (2i-1)^3\right].$$

Several readers applied Newton's finite difference method to obtain the result directly. Shirley Wilson, however, applied a few summation formulas. Since these can be proved easily by induction (in fact, Dennis Kluk submitted a solution with such a proof), I am reprinting Ms. Wilson's solution instead of one using a finite difference:
It is well known that

$$1^3 + 2^3 + 3^3 + \ldots + n^3 = \left[\frac{n(n+1)}{2}\right]^2 \qquad (1)$$

(Consult a CRC, prove by mathematical induction, or teach Calculus I for 6 years!)
Multiplying by 8 produces

$$2^3 + 4^3 + 6^3 + \ldots + (2n)^3 = 2n^2(n+1)^2. \qquad (2)$$

Replacing n by 2n in (1) gives

$$1^3 + 2^3 + 3^3 + \ldots + (2n)^3 = n^2(2n+1)^2. \qquad (3)$$

Thus, from (2) and (3) we have

$$1^3 + 3^3 + 5^3 + \ldots + (2n-1)^3 = n^2(2n+1)^2 - 2n^2(n+1)^2 = n^2(2n^2-1).$$

$$S(m) = \sum_{n=1}^{m} n^3\left[\sum_{i=1}^{n} (2i-1)^3\right] = \sum_{n=1}^{m} n^3[n^2(2n^2-1)] = \sum_{n=1}^{m} (2n^7 - n^5)$$
$$= 2\sum_{n=1}^{m} n^7 - \sum_{n=1}^{m} n^5.$$

These summations have closed forms listed in a CRC, yielding

$$S(m) = 2\left[\frac{m^2}{24}(m+1)^2 (3m^4 + 6m^3 - m^2 - 4m + 2)\right] - \frac{m^2}{12}(m+1)^2(2m^2 + 2m - 1)$$
$$= \frac{m^2}{12}(m+1)^2 (3m^4 + 6m^3 - 3m^2 - 6m + 3)$$
$$= \frac{m^2}{4}(m+1)^2(m^4 + 2m^3 - m^2 - 2m + 1)$$
$$= \frac{m^2}{4}(m+1)^2(m^2 + m - 1)^2$$
$$= \left[\frac{m(m+1)(m^2+m-1)}{2}\right]^2$$

Also solved by Frank Rubin, Gerald Blum, George Braun, James Landau, Richard Hess, Emmet Duffy, Winslow Hartford, Frank Carbin, and Irving Hopkins.

D/J 5 The following problem is equivalent to the question of which powers could be computed on a direct-algebraic-notation calculator using parentheses but not numerical keys, memory, or logarithm-based exponentiation keys. (For instance, the seventh power of a number in the x register can be calculated by the sequence: +, x^2, x^2, x^2, x⟷y =.) We define the following operations on ordered triples (A,B,C) of positive real numbers.

Mult: (A,B,C) ⟶ (A×B, O, C)
Div: (A,B,C) ⟶ (A÷B, O, C)
Load: (A,B,C) ⟶ (A, A, C)
SQ: (A,B,C) ⟶ (A^2, B, C)
LP: (A,B,C) ⟶ (A, A, A)
RP: (A,B,C) ⟶ (A, C, O)

Say n is admissible if for all z > o, (z^n, o, o) can be obtained from (z, o, o) by fixed (not depending on z) sequence of the above operations. For instance, the algorithm for N = 7 is LOAD, SQ, SQ, SQ, Div. The problem is to find the smallest non-admissible integer.

Richard Hess sent us the following:

M: (A,B,C) ⟶ (AB, OC)
D: (A,B,C) ⟶ (A/B, O, C)
LO: (A,B,C) ⟶ (A, A, C)
S: (A,B,C) ⟶ (A^z B, C)
LP: (A,B,C) ⟶ (A, A, A)
R: (A,B,C) ⟶ (A, C, O)

(1) Any exponent of A of the form $2^{n_1} \pm 2^{n_2} \pm 2^{n_3}$ is obtainable through applying S n_3 times, then LP, then S $n_2 - n_3$ times, then LD, then S $n_1 - n_2$ times, followed by MRM, DRD, DRM or MRD.
(2) Any exponent of the form $\prod_j (2^{m_1} \pm 2^{m_k})$ is obtainable through applying S m_j times, then LO, then S $m_i - m_j$ times, followed by M or D.
(3) Any exponent of the form $\prod_j (2^{m_i} \pm 2^{m_j}) \pm 1$ can be obtained by preceding steps (2) with LP and following it with RM or RD.
(4) Any exponent of the form $(2^{n_1} \pm 2^{n_2} \pm 2^{n_3}) \prod_j (2^{m_i} \pm 2^{m_j})$ can be obtained by applying steps (2) after steps (1).
(5) Any exponent of the form $(2^{n_1} \pm 2^{n_2} \pm 2^{n_3}) \cdot (2^{m_1} \pm 2^{m_2} \pm 2^{m_3})$ can be obtained by applying steps (1) and then applying them again for m_1, m_2, and m_3.
(6) A sieve of Erotosthenes approach produced the following list of inadmissible n up to 1100: 157 173 227 229 233 277 283 313 317 331 346 347 353 367 389 397 439 443 454 457 461 463 467 471 523 547 554 563 569 571 593 607 617 628 643 653 659 661 662 677 683 691 692 694 706 709 727 733 739 773 778 787 794 797 821 823 827 829 831 853 857 859 877 878 886 887 907 908 911 914 916 922 926 932 934 937 939 941 942 947 967 977 983 997 1013 1046 1059 1061 1063 1066 1069 1091 1093 1094 1097 1099

It seems to the editor that if two exponents e_1 and e_2 can be achieved, so can $e_1 e_2$ by applying the steps for e_2 after those for e_1. Thus, from Hess's (1) and (2), we get $\prod_j (2^{m_1} \pm 2^{m_2}) \prod_{j,k} (2^{n_i} \pm 2^{n_j} \pm 2^{n})$. I don't know if this raises the limit above 157. Also solved by P. Jung and Naomi Markovitz.

Better Late Than Never

Y1979 Harry Hazard notes that we used − for + in 8, 17, 21, 22, and 89; and x for − in 74.
A/S 2 James Landau has shown that 86 is the minimum number of days needed even if supply packages can be broken up. In fact, for this situation the number of days needed to cross a 20n + 40 mile desert is

$$2 + \sum_{i=1}^{n} 4^i.$$

He challenges Mr. Bahne to solve the problem for 10n + 40.

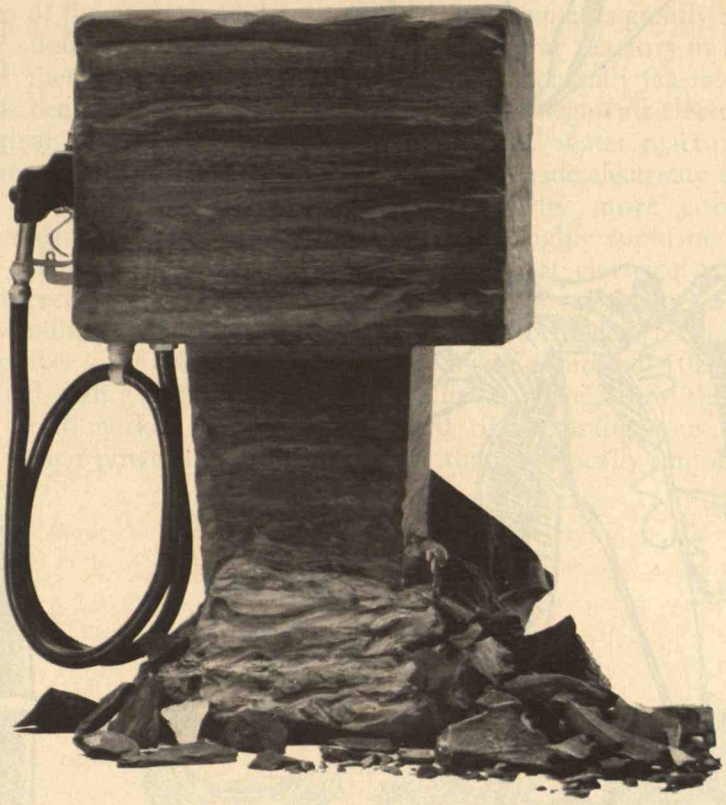
PERM 3 Harry Hazard notes that six lines from the bottom of his published solution the 24 should be a 34. George Gerling sends a listing of all four-digit combinations (base 10) and the number of integers each generates in the range 1 to 100, 101 to 135, and 136 to 200, plus the lowest integer not generated; this listing may be obtained from the editor. His results differ somewhat from those reported by Mr. Hazard (*November, 1979, pp. A31-A32*), and on this subject Mr. Gerling observes:

In the cases where I can prove my results correct I have done so by including an example of an integer produced which Mr. Hazard indicates cannot be produced. I cannot prove the opposite — i.e., in cases where he indicates that an integer can be produced and I think he is in error. The most crucial test of this is his statement that the integer 62 can be generated by the combination 1-3-8-9. My program only produced 98 integers for this combination, and if 62 can be generated I have an error in the program. In this case I would no longer conjecture that the non-base-10 solution I submitted is most likely unique. Specifically, as to Mr. Hazard's results:
(1) I agree.
(2) I believe 1-3-8-9 does not generate 62 and 79.
(3) I agree
(4) I agree with 1-3-7-9; but I find that 2-3-7-9 produces 98 integers: 49 = (9 − 2)**3/7.
(5) I agree with his list except for 2-4-5-7, which generates 97 integers.
(6) The combinations 1-2-7-8 lacks 4, not 5, and reaches to 92: 91 = (21 − 8)*7 and 92 = (12*7) + 8.
(7) I show totals for the stated combinations: 1-7-8-9, 76 (he says 77); 2-4-6-8, 78 (he says 77); and 4-5-8-9, 82 (he says 80).

Proposor's Solutions to Speed Problems

MAY SD 1 The integrals on either side of the last equation are indefinite integrals and therefore may differ by a constant.
MAY SD 2 The resulting graph is a trident or pitchfork held by Satan, Neptune, or the farmer in Grant Wood's famous "American Gothic." Is this a well-known curve? Does it have a name?

We're willing to spend hundreds of millions of dollars to bring you gasoline from oil shale before the end of the 80's.



American oil shale reserves contain more oil than all the crude oil reserves of the Middle East. The greatest concentration of this shale is located in western states such as Colorado. On just one 5,000-acre tract where Amoco and its partner are working, there's enough shale to produce up to 5 billion barrels of oil—making it one of the richest oil reserves in the United States.

Right now we have $100 million and nearly six years invested in our pilot oil shale plant. We're willing to spend hundreds of millions of dollars more to make this plant a commercial reality.

New American oil below world prices

The technology exists to separate refinable oil from shale. And in spite of the tremendous cost, we believe that we can eventually deliver this oil at prices below what we will be paying for foreign oil.

But there's a problem beyond technology that must be addressed before we can move ahead much further. And this problem is created by what we believe is the government's unrealistic level of regulatory paper work.

The initial approvals we received to develop the site we're working are good only for experimental production. Before we can begin commercial output of 76,000 barrels per day, we have to go through the whole process all over again.

Over 120 permits just to get started

The first time around we had to obtain more than 120 permits and approvals before we could begin our work. Compiling the environmental data alone cost over $5 million and took more than 2 years.

When regulation gets to the point where it obscures the original purpose—in this case, developing new American energy—then it's time to put things back in perspective. America can't afford to drag its feet any longer. Foreign oil is becoming more expensive by the month and continues to threaten the security of our country.

The sooner we can get on with the job of producing new American energy, the sooner we can help end this dependency. That is why we plan to spend even more money in the 1980's to make gasoline from oil shale. We want to make it available on a large scale in this decade.

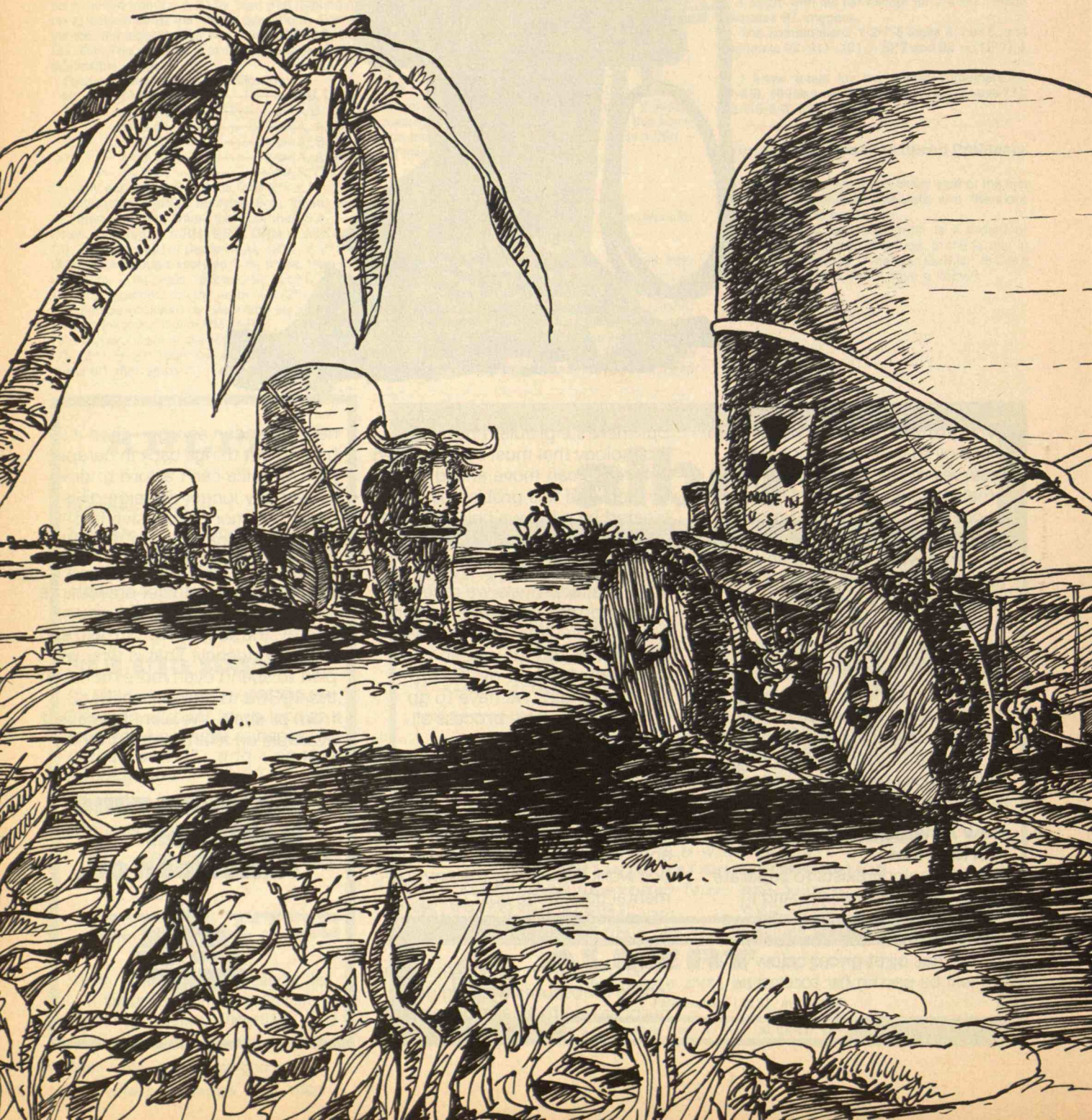
America runs better on American oil.

AMOCO

Nuclear Power for the Third World?

by Joseph R. Egan
and Shem Arungu-Olende

This powerful, complex technology will be less than a panacea to energy-hungry Third-World nations confounded by the rising price of oil.



Ever since the beginning of nuclear power in the 1950s, the industrial nations have tempted the developing countries with visions of the atom providing a cheap, abundant, clean, and safe source of power — a stepping-stone to energy self-reliance. More recently, that vision has been tarnished: the applicability and need for nuclear power as an element of economic development are now seriously in question.

Yet even as these uncertainties gain credibility, many of the so-called less-developed countries (LDCs) are experiencing unprecedented opportunities to supplement their dwindling conventional energy supplies with nuclear power — if they have not done so already. Confronted with a barrage of new regulations, a stagnant Western market, and an uncertain political future for nuclear power in their own countries, reactor vendors have turned to the more lucrative Third-World market. And two new technical developments greatly expand the potential market for nuclear reactors in the Third World by making them technically feasible for small electrical systems: a 200-megawatt-electric (MWe) prefabricated pressurized water reactor that can be mass-produced to provide electricity at costs approaching those realized by more common 1,000-MWe models; and a highly sophisticated sequential-logic control system for electrical transmission systems. Together, these developments could expand the potential market for nuclear reactors in the developing countries by an additional 100 units or more in this century. In so doing, they threaten to retard development of the indigenous technological infrastructure that is critically important to LDCs.

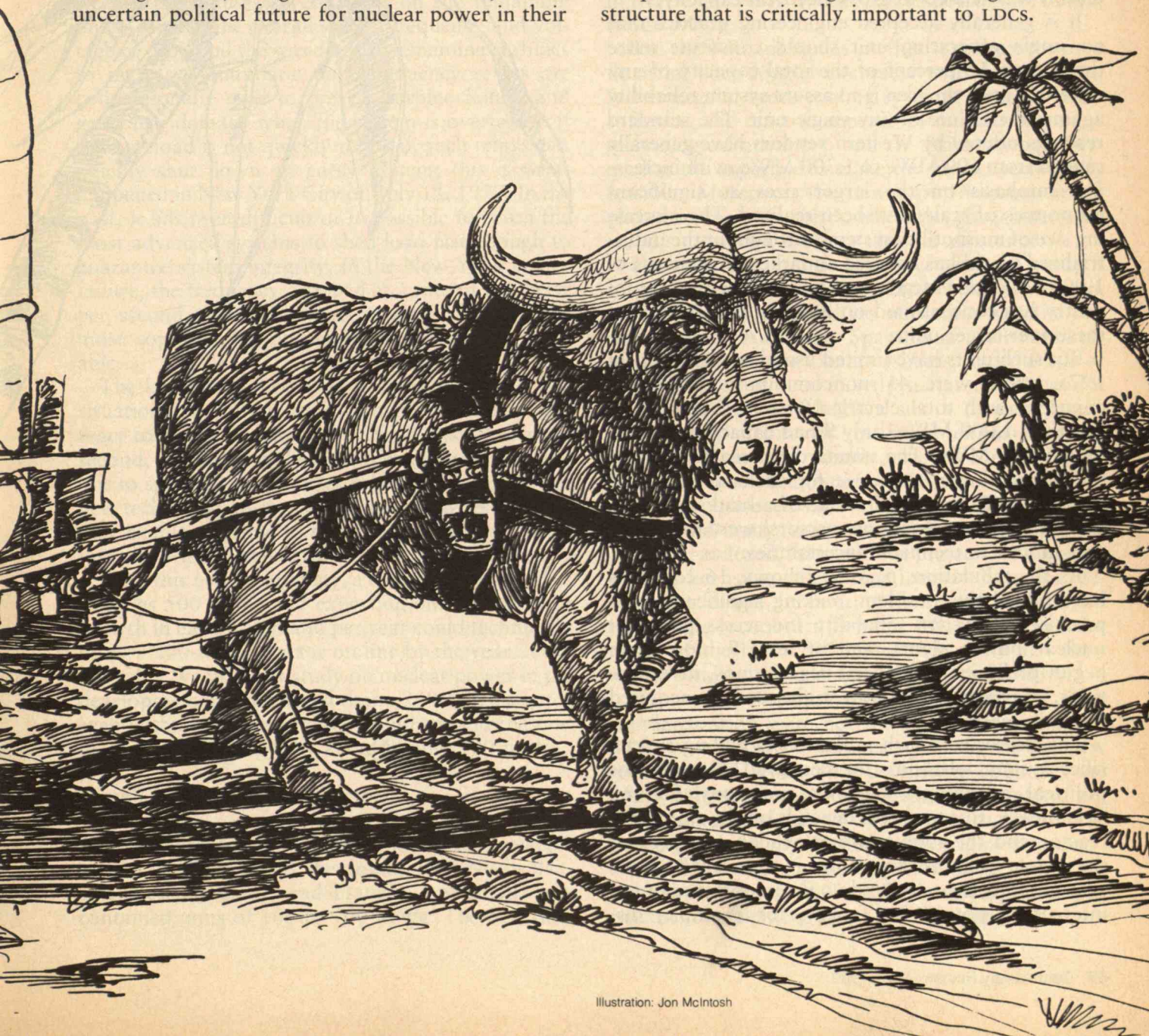
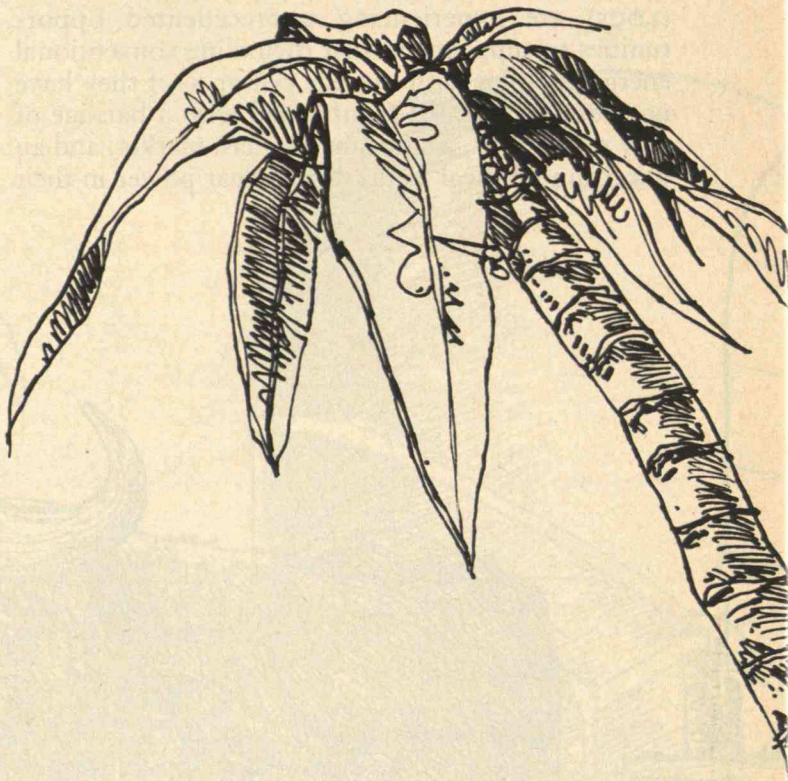


Illustration: Jon McIntosh

Peace Through the Worldwide Atom

The most important supplier of small reactor technology to the Third World may turn out to be from the East, not the West.



Beginning with President Eisenhower's "Atoms for Peace" program in 1953, the United States has consistently promoted and subsidized the export of nuclear technology to the Third World. By 1958, the Atomic Energy Commission had agreements for nuclear trade and cooperation with 43 countries, and research reactors, nuclear fuel, and technical training had been provided to Argentina, Brazil, Taiwan, Iran, Korea, Pakistan, Israel, and Spain. But despite this commitment, nuclear power was introduced slowly in the developing countries. The reason was related to gross electrical capacity.

It is generally accepted engineering practice that no single generating unit should constitute more than 10 to 12 percent of the total capacity of any electrical grid; the idea is to assure system reliability against the failure of any single unit. The standard reactors offered by Western vendors have generally ranged from 600 MWe to 1,300 MWe, with increasing emphasis on the larger sizes as significant economies of scale have been realized. The increasing size of most utility systems throughout the industrialized world has ensured a market for reactors of 1,000 MWe and larger, and most of the nuclear industry has concentrated on building and perfecting these ever-larger units.

But such units have limited usefulness to LDCs. In 1975, there were 41 noncommunist developing countries with total electrical system capacities of less than 1,000 MWe; only 9 had capacities greater than 5,000 MWe. The standardized reactors of the 1970s are simply too large for such systems, and smaller reactors (usually one-of-a-kind modifications of ship or submarine reactors) were too costly and subject to technical uncertainties.

As the tabulation (*page 53*) shows, 16 countries have tabled this problem, making significant compromises in system reliability for access to larger nuclear power plants, and at least 9 more have begun preliminary financial negotiations, investigations, and technical support studies or have acquired research reactors.

The degree to which a country is willing to sacrifice system reliability for perceived economic or political advantages depends on many factors. Technically, this trade-off depends on the size of the reactor and the sophistication available to prevent the system from breaking down in the event of a loss of generating capacity, and on the importance of uninterrupted power. In Turkey, for example, dis-

patchers regularly shed large sections of load on a rotating basis during hours of peak demand to prevent collapse of the system, an indication that small-scale interruptions in power are tolerable. But uninterrupted power remains a high priority in almost all developing countries because it is essential for industrial production and services such as health care and transportation.

New load-shedding technology now substantially reduces the risk of concentrating a large proportion of a system's capacity in a single generating unit. With conventional distribution technology, a sudden 10-percent loss of generating capability on an electric grid causes severe stress on the remaining units, causing the overall system frequency and voltage to drop and the speed of the remaining turbines to increase. Automatic underfrequency relays are conventionally used to prevent turbine failure and generator damage when the system is overtaxed. If the overload is not quickly reduced, such relays can quickly shut down an entire system; this is what happened in New York City on July 13, 1977. In the past, it has been difficult or impossible for even the most advanced systems to shed load fast enough to guarantee system integrity. In the New York power failure, the frequency dropped at a rate of five hertz per second, faster than the response times of the most sophisticated automatic systems then available.

The latest load-shedding technology changes this situation. The relays are so sensitive that they will react to frequency changes of four to six hertz per second, and sequential logic circuits prevent tripping due to spurious noise spikes. The significance of this new technology to the developing countries is that it may enable a system to maintain integrity despite a loss of 15 to 20 percent of its generating capacity.

With this new technology, a country with a grid as small as 500 MWe and expecting only a 5 percent growth in electric demand per year could technically bring a 200-MWe reactor on line by the year 2000. Indeed, a World Bank study on nuclear power in the developing countries noted that a 200-MWe reactor even without the new relays would expand the LDC market through 1990 by an additional 100 units.

"Small Is Beautiful" in Reactors

A still more important trend in nuclear reactor technology for LDCs is the development — in Britain, West Germany, and France — of small, self-contained units of 100 to 500 MWe. The first such system — a 200-MWe prelicensed, standardized, prefabricated, barge-mounted pressurized water reactor for application to small electrical systems — was announced over a year ago by Great Britain's Rolls Royce, Ltd. (RRL), a new conglomerate consisting of Rolls Royce and Associates, Babcock and Wilcox, U.K. Babcock, Foster Wheeler, Vicars, and most recently Combustion Engineering. Major policy centers paid little attention to the announcement; conventional nuclear reactor technology had already demonstrated significant economies of scale, and the concept of an "appropriate" small reactor had long since been abandoned. The smallest plant financed in over eight years by the U.S. Export-Import Bank is 626 MWe.

But the RRL design is neither a technical nor a financial boondoggle. Complete with containment, full emergency core-cooling systems, and the latest software, the reactor appears to require no major technological advances, and the British conglomerate has the expertise to make the project technically feasible. Moreover, the new group became firmly placed in the civil sector when the government assured substantive product support assistance.

Hardly a year after its announcement, the group is forging ahead with a nine-year development plan, having already engaged in marketing negotiations with China, Australia, Spain, and such unlikely areas as Ghana, the Canary Islands, and the Isle of Man. RRL envisioned exactly such a market and it found the 200-to-300-MWe size a reasonable extrapolation from its military experience. It capitalized on this smaller size by designing an "assembly-line" barge-mounted reactor that would shorten construction time (down to five years or less), avoid many costs associated with site-specific, customer-tailored, large reactor projects, and permit generic licensing, alleviating lengthy licensing delays. In addition, by limiting their production effort to a single location in Britain, RRL hopes to calm many of the labor difficulties that prompted their withdrawal from the stagnant military industry.

Size and the special economies associated with standardization were not the only factors that led RRL to see LDCs as the perfect hosts for the new reactors. RRL knew that developing countries are often willing to make concessions on safety, environmental, and security regulations that would be unacceptable in any Western industrialized country, especially if those concessions implied significant reduction in costs. In West Germany, for example, reactor containment must be 78 inches thick to

withstand the possible crash of an aircraft the size of an F4 *Phantom*. In Brazil, however, the Angra nuclear plant being built by West Germany's Kraftwerk Union will have a containment structure only 31 inches thick. The Philippines is constructing a 620-MWe Westinghouse reactor on a site that may well be one of the most seismically and volcanically active spots in the nation — a site that would never be allowed in the U.S.

Costs of the RRL design remain uncertain. Estimates as of March 1979 (for a nominal 200-MWe reactor in standard configuration, complete with plant, generating equipment, barge, fuel-handling equipment, site work and preparation, technological support and procurement, and transportation) range from £975 per kilowatt-electric (KWe) using 10 percent interest rates to £1,120/KWe using 15 percent interest rates. These figures translate to a total cost of about $2,400/KWe.

Is this cost high relative to the large units? Perhaps not. In the U.S., 1,100-MWe plants now in the early planning stages are anticipated to cost from $1,600 to $2,000/KWe. An attractive bonus has been added by RRL for potential customers: the company will furnish, free of charge, a kerosene-burning generator of equal capacity on the site until the prefabricated reactor arrives, ensuring immediate 200-MWe capability. The customer must pay only for the fuel.

RRL hopes to be ready for mass production, barring licensing difficulties for a demonstration plant in Britain, in nine to ten years. If those difficulties materialize, they will probably come from the Nuclear Installation Inspectorate (NII), the safety authority for British civil nuclear projects. The problem is that small reactors, like their submarine counterparts, are notorious for the high radiation exposure of plant personnel. (The total annual man-rem dose for the RRL demonstration project could be as high as 1,300, requiring several times the labor needed to operate and maintain a comparable plant in the U.S. or resulting in significant overexposure of workers.) If NII forces the issue, the company may be prompted to locate its first prototype plant in a developing country. Indeed, it is already investigating this possibility.

Competition for RRL in the small reactor business is already in sight. The French firm Alsthom-Atlantique has a 125-MWe demonstration plant at the Cadarache Nuclear Laboratory, and the German firm Interatom is planning to produce a 60-MWe reactor based on the reactor in the nuclear-powered ship *Otto Hahn*. Most recently, the Kraftwerk Union organization has announced plans for a barge-mounted 200-MWe reactor, a novel and unproven combination of existing reactor technology, for sale to developing countries.

But the most important supplier of small reactor technology to the Third World may turn out to be from the East, not the West. It was in 1970 that the Soviet Union contracted with Finland for the sale of Loviisa 1, a 440-MWe reactor better known as the VVER-440. The total cost was estimated by the Central Intelligence Agency at 500 million marks, or roughly $250 million ($570/MWe) in 1970 dollars. The Finns obtained financing to build Loviisa 1 from the Soviets at 2.5 percent interest over 20 years, an arrangement vastly superior to any available on the Western market. Of the total sale, subcontracts worth 37 million marks were returned to Finnish firms, particularly for the development of quality-control items, for which the Soviets have traditionally lagged behind Western industrialized countries.

Today, the Finns are solidifying a partnership with the Soviet Union to develop the VVER-440 for export. Already the reactor is being deployed in the Eastern Bloc countries on a wide scale, and the Finns are assisting the U.S.S.R. in the development of nuclear power programs in Libya and Iraq (*see table on page 53*). Soviet intentions to export the reactor to the West have been openly acknowledged. Already the U.S.S.R. has allegedly engaged in negotiations with Nigeria for the sale of a VVER-440, a sale that would have important political implications throughout Africa.

The VVER-440 contract calls for uranium and reprocessing services to come from the Soviet Union, purchased with loans at 2 percent interest and at enrichment prices that are 5 to 15 percent below published U.S. prices. Spent fuel is to be shipped back to the U.S.S.R.

These attractive financial terms and fuel arrangements appeal to many nations interested in diversifying their reactor and fuel supply sources; hence, the U.S.S.R. is gaining a competitive edge in both reactor and enrichment markets.

Overoptimism for the Atom?

What is the appeal of nuclear power to an LDC, and why are developing countries willing to make sacrifices to obtain a reactor when most of the industrialized countries are having trouble keeping their own nuclear industries afloat?

Potential reactor vendors appear to be counting on safety concessions from the Third World as one means of reducing costs.

In answering that question, officials invariably emphasize economic issues. Many LDCs depend almost wholly on imported energy resources, and they see nuclear power as essential to diversifying their energy supplies. They perceive their own national energy needs and the dangers implicit in heavy reliance on tenuous fuel supplies as overriding their concerns for nuclear safety and environmental problems, which they believe will soon be resolved. Some countries are now using these arguments to rationalize irreversible commitments that do not seem as valid as they once did. Electricity and energy demand projections in the developing countries have consistently been too high, making the need for new generating units appear greater than it actually is; estimates of the International Atomic Energy Agency (IAEA) have historically been high by a factor of two or more. These errors can be attributed primarily to the assumption that large energy growth will be synonymous with rapid economic growth in the LDCs (but much of the LDCs' economic growth is accomplished with labor and other substitutions for energy), and to the fact that many small, unmetered customers have not been accounted for.

Other, less-obvious reasons for the appeal of nuclear power may be equally or more compelling. The fact that nuclear power is becoming less attractive in the industrialized countries means that the nuclear industry can survive only by aggressive marketing in the developing countries, which are often faced with "offers they can't refuse."

Another reason for the current optimism over nuclear power in the LDCs stems from the assumption by many leaders that LDCs should grow in the image of the advanced industrial societies, which followed practices that implicitly assumed, for valid historical reasons, the availability of cheap energy. This development strategy led to an emphasis on capital- and energy-intensive heavy industry, requiring the creation of electric generating facilities. Until recently, essentially all World Bank loans were restricted to electricity production and distribution systems, as were most projects supported by the Agency for International Development before the early 1970s. An overwhelming fraction of all assistance to the LDCs in energy still goes to the electric sector. Development agencies and banks have thus played an important role in legitimizing nuclear energy development through their lopsided financial support.

One can also hypothesize that nuclear technology

has been appealing to LDCs because of the special prestige, important to politicians both internally and externally, that seems to accrue to nations possessing high-level technology. Technological inferiority, real or assumed, can be too hastily equated with political inferiority.

Military issues may also be a critical factor, largely unspoken. Nigeria's recent interest in nuclear power, for example, has been cited as a response to South Africa's apparent proximity to a nuclear weapons capability. Pakistan's former President Zulfiqar Ali Bhutto purportedly admitted that his motivation in buying a French reprocessing facility had been to give Pakistan a nuclear weapons capability, presumably to match that of India. Other confrontations that may have led to the adoption of nuclear power include those of Egypt and Israel, Korea and Japan, Taiwan and China, and Brazil and Argentina.

Both the cost and reliability of nuclear power in the LDCs have been misjudged. During the 1960s and early 1970s, the IAEA used 4 percent inflation rates in economic assessments of nuclear power when inflation rates in many LDCs were topping 100 percent. Though nuclear reactors were achieving only 55 to 65 percent of their rated output in the industrial nations, capacity factors of 70 percent or higher were used in financial studies. Nuclear plant costs and reliability statistics based on Western industrial institutions and operating experience, in any case, proved inapplicable in the LDCs. Delays in receiving new parts from overseas vendors required lengthy shutdowns, skilled manpower had to be imported for routine construction, new institutions to deal with the administrative and quality-control aspects of a nuclear power program had to be created, and long construction times all added their tolls. According to the U.S. Export-Import Bank, not one of its 50-odd nuclear export projects in 16 foreign countries has been completed on schedule.

The safety of nuclear reactors as operated in the Third World deserves a great deal more attention than most of the LDCs and their supplier nations have given it. Each nation operating nuclear power plants has a legal, social, and moral responsibility to safeguard the safety and health of its citizens, for which there are currently *no* internationally agreed-upon safety and radiation protection guidelines. Monitoring, regulating, and enforcing such standards would pose intricate problems, and it is not clear that utilities in the developing countries, having had little or no input into the reactor design and construction process, would have the technical or institutional capacity to operate reactors on the basis of the standards. Furthermore, in the Third World there is a tendency for each country to want to exercise its sovereign prerogative by making or enforcing its rules independently. Indeed, potential reactor vendors appear to be counting on safety concessions from the Third World as one means of reducing costs. This may provide only a short-term strategy.

As more and more developing countries acquire commercial nuclear reactors, the chances of serious health and safety accidents will increase — more so for systems with lax safety standards. Such accidents would deal nuclear energy development throughout the world a serious blow. The cost of retrofitting and updating safety standards would soar, and public confidence would be weakened. If they are associated with deliberate safety concessions, and if their effects cross national boundaries, reactor accidents could have serious political consequences for the affected nations and perhaps for the supplier nations. A related issue, too little considered, concerns the impact of widespread use of nuclear energy on the distribution and exercise of political power in the Third World. This new energy resource, entrusted to private, local corporations or government agencies, will bring increasing power over national economies and will probably exacerbate the uneven distribution of economic power, and with it political power, already a hazard in many Third-World societies. Such capital-intensive, centralized economic power could contribute to the disruption of the socioeconomic infrastructures of Third-World societies — a form of disruption that has recently become all too evident in Iran, for example.

Lastly, the controversial issue of possible proliferation of weapons technology from nuclear power programs will become increasingly significant as present international safeguards, already inadequate and inconsistent, become altogether insufficient to cope with the greatly expanded LDC market. The recent lifting of U.S. trade sanctions against Pakistan, originally imposed because of that nation's intent to proceed with the development of nuclear fuel reprocessing technology, is sure to be seen by many LDCs as further evidence that there are no effective controls over the transfer of nuclear technology; they may well decide to proceed with their own programs before they are outrun by their competition.

Clearly, before coming to hasty conclusions about an attractive new technology, developing countries must take a serious look at the seemingly extraneous problems associated with acquiring, installing, and

Thirty-one nonindustrialized and Eastern-bloc nations have now embraced the nuclear age by building or planning the purchase of nuclear power plants. Most of the reactors now in operation and under construction are of modest size, and the appeal of this technology to Third-World nations has been considerably enhanced by the recent development of small-scale "turnkey" nuclear power plants.

	Reactors in operation		Reactors under construction		Reactors on order		1977 per capita gross national product (U.S. dollars)	Size of electric grid
	No.	Size (MWe)	No.	Size (MWe)	No.	Size (MWe)		
Argentina	1	335	1	600	1	700	$1730	E
*Bangladesh							90	B
Brazil			1	626	1	1245	1390	F
			1	1245				
Bulgaria	2	440	2	440			2590	E
*Colombia							710	D
Cuba			1	440	1	440	900	B
Czechoslovakia	1	110	4	440	1	440	4090	E
	1	440						
Egypt					1	620	310	D
Finland	1	440	1	440			6150	E
	1	660	1	660				
German D.R.	3	440	3	440			4940	E
*Greece							2810	D
Hungary			4	440			2570	E
India	3	200	5	220			150	F
*Iran			2	900†			2180	D
			2	1200†				
Iraq					1	900	4980	B
*Jamaica							1150	A
Libya					1	440	6680	A
Mexico			2	654			1110	E
*Nigeria							420	B
Pakistan	1	125					190	C
*P.R. China							410	F
Philippines			1	620	1	620	450	C
Poland					2	440	3150	E
*Portugal							1850	D
*Peru							830	C
Romania					1	440	1580	D
					1	600		
South Korea	1	595	2	660			810	D
			4	900				
Spain	1	160	2	880	4	1000	3190	F
	1	440	5	930				
	1	480	1	975				
Taiwan	2	636	2	951			1180	D
			2	907				
Turkey					1	440	1110	D
Yugoslavia			1	615			1960	E

Reactors shown in white squares are the U.S.S.R. VVER-440 (see page 50)

*Nations listed without reactors in operation, under construction, or on order are those that have expressed "firm interest" in acquisition. Feasibility studies and/or bidding are also underway by Chile, Indonesia, and Thailand.

†Canceled.

Grid sizes (MWe):
A - 500 to 1,000
B - 1,000 to 2,000
C - 2,000 to 5,000
D - 5,000 to 10,000
E - 10,000 to 20,000
F - 20,000 to 35,000

operating reactors. Such problems have generated only casual interest in much of the Third World, where technology assessment has been considered essentially an issue for the industrialized countries.

Assessing the Economics of Nuclear Power

The question of nuclear power for the LDCs presents some special economic assessment problems. Debt, for example, remains a critical issue. Over the past several years, the debt of non-oil-producing developing countries has reached unprecedented levels — over $250 billion in 1977. By the end of 1978, debts of LDCs held by private banks and international lending institutions such as the World Bank and the International Monetary Fund amounted to over $220 billion, and the debt has continued to mount as world oil prices rise. The additional deficits from the import bill were about $43 billion in 1979, and the deficits for 1980 will be still worse — more than $50 billion. Some decision makers in the developed countries have expressed concern over the risk of instability in the banking systems of their countries; they have thus cautioned against further substantial loans.

This situation directly affects the energy options of the developing countries. One result has been reduced economic growth in many LDCs; this factor — together with the nations' uncertain ability to shoulder a further debt burden — may dampen the enthusiasm for nuclear power and perhaps also the enthusiasm of those who sell it. The Soviet alternative of low capital costs and interest rates may then be especially attractive.

Given this pressure resulting from debt and the growing deficits from oil imports, is nuclear power a sensible alternative for LDCs? True, energy from the atom can replace some of that obtained from oil, especially as a source of electricity. But a harder look suggests that the nuclear option may not solve the problems of LDCs: indeed, a shift to the nuclear option may in some cases accentuate their dilemma. Nuclear fuel will invariably be imported. Nuclear units are capital-intensive, and most, if not all, equipment will be imported. In addition, most technical experts, at least in the initial stages of any nuclear project, will be foreign, hired at international market wages and paid in foreign exchange.

Recent studies indicate that commercial nuclear reactors will require at least one chemical cleaning and decontamination over their 30-to-40-year lifetimes to reduce workers' radiation exposure to safe levels. Preliminary estimates of this cost range from $25 million to $45 million for a 1,000-MWe reactor. Estimates for decontaminating a damaged 1,000-MWe reactor after a major accident range from $100 million to $400 million, including replacement power costs. The structure and costs of an insurance program for nuclear plants are largely unclear: how should the insurance be financed and to what extent should governments share liability?

For these and other reasons, assessing nuclear power costs is indeed complex; there are no agreed-upon criteria, and estimates vary widely. Regulatory costs and government subsidies are hard to translate from one nation to another, and there is no clear indication of how these may vary over time. And two future costs remain unresolved — that of permanent disposal of high- and low-level nuclear waste, and of decommissioning obsolete reactors (estimated to be from $50 million to $100 million for a 1,000-MWe plant).

When all the costs of acquiring, operating, and maintaining a nuclear power program are realistically computed (including security, administration, and regulatory costs), the nuclear picture — at least for the immediate future — may be less attractive than many LDCs assumed. More than ever, decision makers in the developing countries need detailed analyses that include hidden costs and more thorough examination of the assumptions on which these costs are based. Only then will decision makers have credible information from which to make their choices.

The new, small reactors now marketed by Rolls Royce and others promise the cost advantages of a "turnkey" construction system. But such systems must pose a dilemma to many developing countries, for a growing number are ideologically opposed to turnkey arrangements in general. For some, the desire for a nuclear reactor will be strong enough to overcome the misgivings, while others will forego the apparent economic advantages of the turnkey reactor because of their desire to participate in the design and development of the technologies on which they depend.

The current level of debt and the recent sharp increases in oil prices have together stimulated many Third-World nations to examine anew their energy development programs, and many are giving increasing emphasis to energy conservation and rational energy utilization. This should reduce the tendency, prevalent in the past, to overbuild installed generating capacity, and it should also reduce pres-

sures to add new plants, including nuclear units. Furthermore, many plans for future energy development now put a premium on use in rural areas, further reducing the pressure for large-scale, centralized energy systems and capitalizing instead on the LDCs' vast labor resources; unemployment exceeds 20 percent in many countries.

Accelerating Toward Armageddon?

Despite all these conditions, a growing number of LDCs, whose representatives are convinced that nuclear power is a necessary element of their energy programs in the next few decades, are struggling to finance and secure this technology. They are encouraged by the new developments in small reactor technology that are being aggressively promoted by both Western and Eastern interests. Yet a host of serious difficulties associated with nuclear power in the developing world are yet to be resolved. It is impossible to say with certainty that nuclear power will result in net benefits — economic, social, and political variables included — to the LDCs who embrace it. Indeed, many development experts now believe that nuclear power ignores the very problems that are most critical to participatory and sustained development. It might, in fact, diminish resources available to achieve this end.

Despite such growing evidence, efforts to halt or slow the pace of nuclear power growth in the Third World are met with increasing resistance by LDC government officials. This is partly because these efforts are often undertaken in ways that are politically condescending; partly because efforts to control the spread of nuclear technology have been historically grounded in political self-interest or commercial charters, casting doubts on new efforts; and partly because the industrialized countries and international lending centers do not encourage LDCs to pursue nonnuclear and nonelectric energy options. Meanwhile, the developed countries continue to consume ever-larger fractions of the available world oil, not always unmindful of the fact that their increasing consumption and inadequate energy policies are forcing the LDCs into a "do-or-die" dilemma with respect to nuclear power.

Challenges to the political, ideological, and institutional mechanisms that govern the transfer of technology from industrialized to developing nations — frequently dubbed "neo-colonialist" — are too often met with superficial "anti-technology" accusations. Ironically, much of this labeling originates in the West by those whose interest it is to legitimize the status quo.

We do not agree with those who argue that the Third World should do without high-level technology. Nuclear technology, however, is more expensive, more dangerous, and more difficult to manage than most high-level technology. As such, it deserves much more attention. Technology transfer, as we have so often learned the hard way, is not only the transfer of gadgets and machines; it is a complex exchange of cultures and ideologies, mechanical power and political power. In a most fundamental sense, the current pressure for so-called "appropriate" nuclear technology in the Third World may stem from the fact that such a technology attacks only the symptoms of energy starvation, leaving causes intact. □

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Telephone Technology and Privacy

by Oliver G. Selfridge
and Robert T. Schwartz

More wiretapping is going on than people realize or even like to think about. No one can assure the privacy of telephone conversations, and new technology to help is complex and expensive.

Illustrations: Bernie LaCasse

The telephone is fundamental to communication in society. Technological advances assure that this role will continue to grow, providing more sophisticated and potentially more useful communications to consumers but becoming harder to understand and control. The public has a right to expect that these communications are and will be private.

That expectation is not being fulfilled. The present system of regulation and supervision cannot assure the public of its rights. We argue that the public ought to know how private its telephone conversations are, and it needs to agitate for changes in the attitudes and practices of regulatory bodies. People need to learn how to protect themselves; we should require that our regulatory agencies know what is going on and be able to verify that the public good is being served. We cannot rely on telephone company assurances that everything is all right. Everything is not all right, and the public would need protection even if it were.

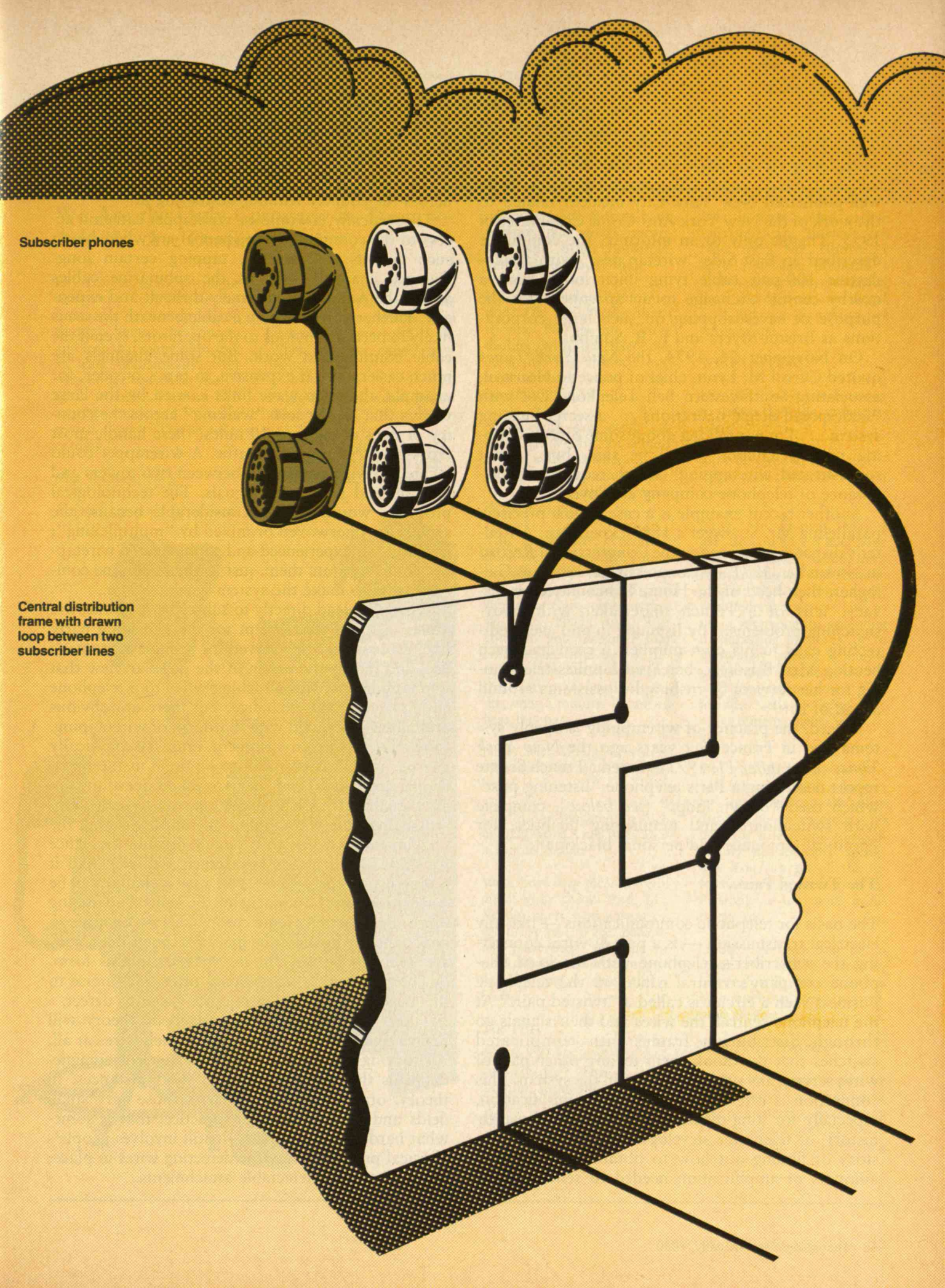
A Little History

Telephone surveillance has a long history; it started almost as soon as the telephone came into use. In 1889, a Kansas City undertaker named Almon P. Strowger was disturbed to find that the telephone operators, who had ready access to his telephone conversations, were tipping off his competitors so that they could snatch bodies before he could get to them. With the true genius of an entrepreneur, Mr. Strowger responded by designing a switch that permitted calls received at his telephone company's central office to be shunted to his line mechanically, without operator intervention. Thus the automatic central office was born.

Ever since then, newspapers have reported many instances of wiretapping, some even at the highest levels of government. Yet the extent of current wiretapping activity within the U.S. is far from clear.

In *The Ominous Ear*, Bernard Spindel cites a

Subscribers' lines are brought into telephone central offices through distribution frames. Manual, mechanical, or electronic switching within the central office serves to connect one point on such a distribution frame with another and so bring two subscribers into communication. A permanent connection — a "drawn loop" — between two points on such a distribution frame causes two telephones to be served in parallel; thus an answering service can respond to a subscriber's call when necessary. Such drawn loops proliferate in central offices, and they can be used for nefarious as well as legitimate purposes.


Subscriber phones
Central distribution frame with drawn loop between two subscriber lines

well-publicized New York City incident related to the work of the New York Anti-Crime Committee in 1955. Thanks only to an informer, the committee described an East Side "wiretap nest" with a clandestine 100-pair cable tying illicit loops from a nearby central exchange to an apartment for the purpose of eavesdropping on such large corporations as Bristol-Myers and E. R. Squibb.

On November 24, 1974, the *New York Times* quoted Carrol M. Lynn, chief of police in Houston, associating Southwestern Bell Telephone Co. with "widespread illegal operations . . . a secret bugging system . . . I'm not talking about some officer climbing up a telephone pole," he said, but "about sophisticated wiretapping" which required the assistance of telephone company employees.

Another recent example is a case almost precisely paralleling Mr. Strowger's 1889 experience. A Reuter's dispatch published in the *Congressional Record* in November, 1971, by Congressman Cornelius Gallagher, then head of the House Subcomittee on Privacy, tells of a French undertaker with body-snatching problems: "By listening in and even redirecting calls to his own number, a rival had been beating Mrs. Brison to bereaved families telephoning for her services by rushing his assistants around ahead of her."

Indeed, the practice of wiretapping is openly systematized in France. Six years ago the *New York Times* (*November 11, 1973*) quoted a French Senate report describing a Paris telephone "listening post" which used "drawn loops" (*see below*), complete with switchboards and monitoring facilities, for "political espionage and personal blackmail."

The Twisted Pair

The basis for telephone communications — like any electrical transmission — is a pair of wires connecting the subscriber's telephone with the local telephone company's central office; in the telephone business such a circuit is called a "twisted pair." At the telephone central, the wires and their signals go through distribution frames into complicated switches that can hook them to any other pair of wires serving any other telephone in the system. This connection is often done with some amplification, especially for long-distance calls. Indeed, the early history of telephone development was largely the story of finding out how to obtain the enormous amounts of amplification needed to send a signal across the country without destroying it.

Theoretically, a would-be wiretapper can gain access to the communication channel anywhere along such circuits. In practice, tapping certain long-distance channels such as the submarine cables across the Atlantic is extremely difficult and expensive. Furthermore, a tap on a cable beneath the sea is likely to become obvious to the operators, even if the cable continues to work. But some channels are much easier, even if expensive, to tap. Consider, for example, the microwave links carried by the large towers that can be seen "walking" across the country in steps of perhaps 30 miles; these handle most cross-country telephone traffic. A wiretapper could locate receiving equipment between two towers and pick up and record the signals. The technological problems would still be considerable because the signals are interwoven or mixed by "multiplexing"; however, an experienced and sophisticated wiretapper could separate them, just as the telephone company does to make the system work.

Wires that lead directly to subscribers' phones are much easier to tap. Except for the vanishing party line, those wires are reserved for a single customer's use, and that is the origin of the popular view that wiretapping involves attaching wires to a telephone circuit outside the exchange. But there are obvious difficulties associated with that form of wiretapping. First, the circuit environment must be physically altered, which usually has to be done in the open. People are visible, and they are asked questions; an alert guard or even a curious passer-by can jeopardize any such wiretapping operation. Second, the attachment of wires to a circuit outside the office sometimes changes its impedance (i.e., the load it represents on the system), and such a change can be detected by test equipment in the central switching office. Because telephone companies use changes in impedance to indicate the quality of their lines, they are likely to be alert to interference in this form. Furthermore, such wiretapping often adds noise to the lines, making the interference easier to detect.

Those familiar with electromagnetic theory will realize that it is not necessary to attach wires at all. All varying electric currents generate electromagnetic fields that are detectable at short distances. In theory, one merely has to detect those very small fields and amplify them. In practice, that is somewhat harder than it sounds. It still involves people's physical presence to set the detecting wires in place; but it eliminates detectable attachments.

We Are the Only Company in Town — And We Are Omnipotent

Lily Tomlin, as the telephone company's indomitable Ernestine, has expressed through humor the concern and fear that many of us feel, at least occasionally, over Alexander Graham Bell's great invention. Here are two routines condensed from her record album, "This Is a Recording."

Mr. Veedle

A gracious good afternoon, Mr. Veedle. This is Miss Tomlin at the telephone company. Mr. Veedle, you owe us a balance of $23.64. When may we expect payment?

Pardon? When *what* freezes over?

Oh, Mr. Veedle. I don't see why you're kicking up such a ruckus when, according to our files, your present bank balance, plus stocks, securities, and other holdings, amounts to exactly three —

Pardon? Privileged information? Oh, Mr. Veedle, that's so cute! No, no, no. You're dealing with the telephone company. For instance, as I look through your income tax return for 19 —

Mr. Veedle, you don't understand. We are not subject to city, state, or federal regulations. *We* are omnipotent. That's potent, with an om*ni* in front of it.

You know, Mr. Veedle, I think we can persuade you to pay after all. I want you to listen to a little recorded conversation. Can you hear that all right? That's right, it *is* you. Do you recognize that *other* voice? And do you remember the basic content of that conversa — wait a minute, wait a minute. I want to hear this part again.

Now, Mr. Veedle, if you're interested, we have 96 hours more.

Oh, I think blackmail is such an ugly word. Let's just call it a vicious threat.

Well, how very nice. We will await your check. And, Mr. Veedle, there's no reason on earth for you to feel personally persecuted. We may be the only telephone company in town, but we screw *everybody*.

The FBI

Is this Mr. Hoover? Mr. Jedgar Hoover? This is Miss Tomlin from the telephone company. It is my duty, Mr. Hoover, to discuss with you some of the abuses of your instrument.

Yes, it does sound rather un-American, doesn't it? Now then, Mr. Hoover, I have a delicate problem. I find that you and your agents have indulged in the illegal and unfair practice of wiretapping.

WIRETAPPING!

Oh, Mr. Hoover — listening to other people's conversations!

How do I know? From listening to your calls; that's how I know.

Now, Mr. Hoover. May I ask, do you have a telephone directory handy? Good. Let's turn to page *viii* and recite in unison: "It is a crime, under both federal and state law, to use a telephone for annoying or harassing purposes, or to knowingly permit a phone under one's control to be used for such purposes. This includes calls in which the caller remains silent," etc. etc. etc.

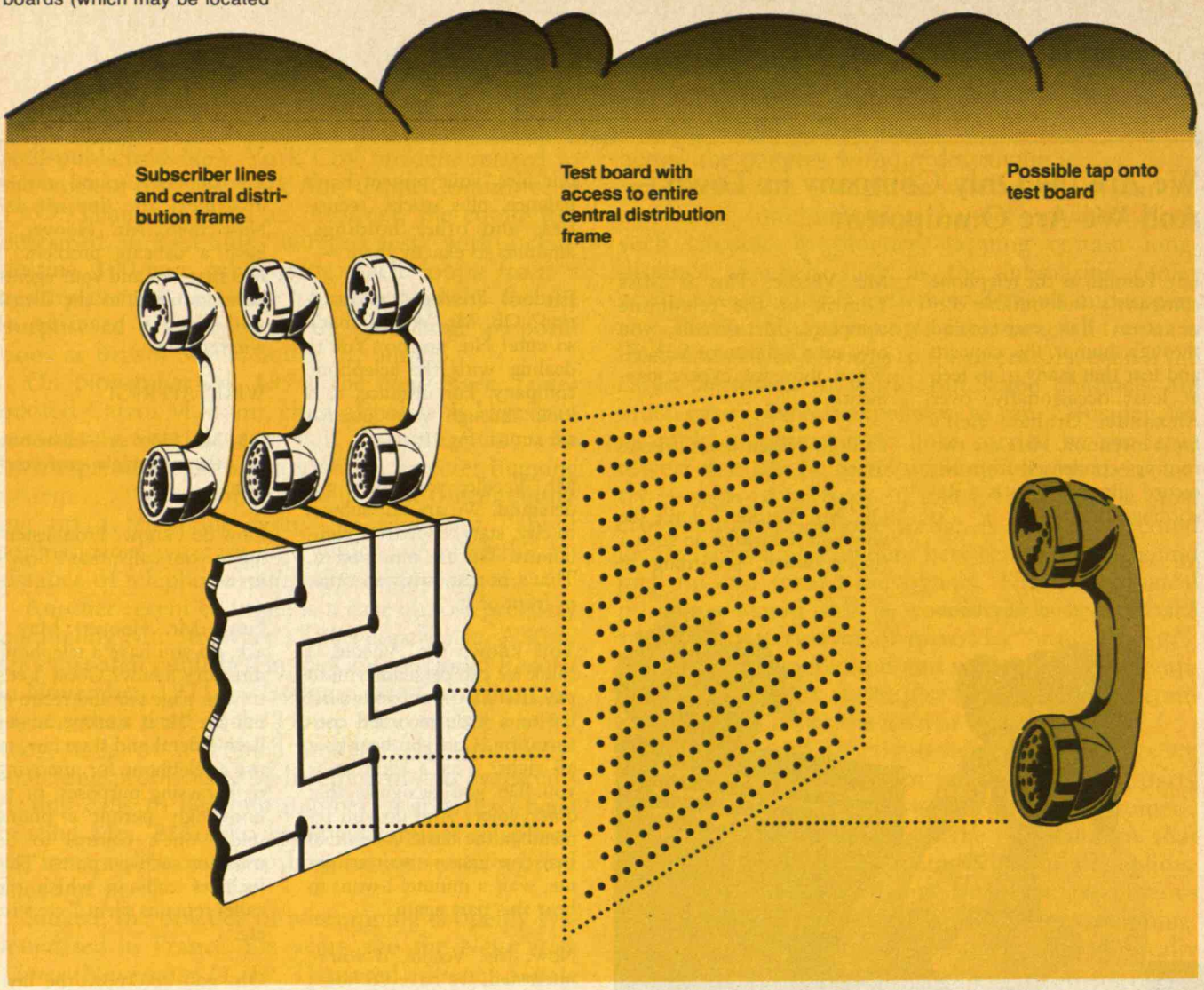
Oh, you *do* know the law, Mr. Hoover. Now, Jedgar, let's get right to the nitty gritty. There's absolutely no need for your people to skulk about, electronically speaking. You can get all the information you need from *us*. Probably a lot more accurately, too.

Good. Then we will be in touch. Oh, and Mr. Hoover, before you go, I must tell you how much I admire your vacuum cleaner.

Hello? Mr. Hoover?

Well, why do you suppose he got so huffy? I was just being complimentary. Everybody knows there's nothing like a Hoover when you're dealing with dirt. □

As mechanical switching gives way to electronic switching of telephone connections, a new feature is added — special test boards (which may be located remotely from the central office), through which technicians have access to all subscribers' lines in monitoring the system's operations. Using such a test board, a telephone engineer or repairperson can gain access to any single line or many lines sequentially, and wiretappers and espionage agents have a whole new range of opportunities.



The Drawn Loop

There is one place where a wiretapper can work without having to be sure that the public doesn't know he's there. That is within the central telephone switching facility itself. Most customers assume that interference doesn't happen inside company property without the company knowing about it, but as we shall see, that is not always the case.

The usual method of interception at the telephone central office is called "drawing a loop," and it consists simply of adding another pair of wires in parallel with those from the subscriber's phone where they appear within the terminal on the central office main frame. Since it forms part of the equipment at the central office, and since it is properly integrated with the other circuits most of the time, such a "drawn loop" is technically indistinguishable from legitimate company equipment. Furthermore, since there are many proper reasons for installing such a "drawn loop," illegal loops installed for nefarious and questionable reasons are impossible to distinguish from the legal ones. Because of this, and because of lack of oversight, it is difficult to determine the prevalence of illegal drawn loops.

Many telephone companies use drawn loops to check the quality of their service. In most states, company service observers are usually allowed to listen in on switchboard traffic only for the purpose of checking the quality of the line — making an evaluation of whether the speech signals are being corrupted by interference, and so on. Management policy about checking service varies from state to state and among the several companies in the Bell System. In general, telephone companies claim to have fairly strict rules about how long service observers can listen; but the important fact is that the capability is inherent: a supervisor may listen in on any conversation without being detected by the subscribers. Furthermore, it is the phone company that makes the rules and that also checks on whether they are being obeyed.

Drawn Loops and Answering Services

Answering services are another significant class of users of drawn loops. They proliferate in every major city; nearly 300 are listed in the Boston "yellow pages," and the Manhattan classified directory offers 19 pages of answering services. To start such a service, you need only rent an office, obtain a plug-and-cord switchboard, and have the phone company install a multiconductor private cable to the main distribution frame in the central telephone office serving the customers you wish to serve. Your answering service can begin as soon as wires are added between your cable and your customers' lines on the central office distribution frame, so that you have a parallel access to each of your customers' lines. Procedures vary for allowing answering services access to telephone company lines for such purposes. We checked California, Michigan, Massachusetts, and Virginia and found that telephone companies in each state have different procedures. In Virginia, for example, the Chesapeake and Potomac Telephone Co. requires no written authorization whatever from either the answering service or the subscriber. It requires only the use of a so-called "J-relay" at the answering service switchboard; this opens whenever the subscriber uses the phone, disconnecting the loop to the answering service operator and thus preventing eavesdropping. However, defeating the "J-relay" is trivial; and there is no inspection of answering services and their use of the device once the installation is made. We presume that most answering services are totally legitimate. But the possibilities for abuse are unlimited; moreover, anyone can masquerade as an answering service and use for illegitimate purposes the drawn loops provided by the telephone company.

New Possibilities: Software Switching

Electromechanical switches that have their ancestry in Mr. Strowger's anti-eavesdropping device are now being replaced by electronic versions that act far faster and more reliably. Perhaps 50 per cent of U.S. telephones are now served by electronic switching systems (ESS), in which messages are controlled, audited, and transmitted electronically under computer control — that is, with no electromechanical components at all. Since almost all ESS operations are automated, few people are present to interfere with illegal activities, and there are no physical ways to tell if a communication link is being intercepted — no soldered connections, no switches that visibly change position, no relays that obviously make and break connections.

New capabilities and opportunities for eavesdropping and sabotage are emerging with these ESS systems, but reliable information about them is scanty. Soon after the first electronic switching system exchanges went into service in 1966, we discovered that the "test board" typically associated with an ESS exchange (though perhaps located remotely) could become an extraordinarily powerful tool to an eavesdropper or saboteur. The test board is designed to permit technicians to remotely access each line within an exchange, to switch automatically among lines, and to gain access to lines sequentially. A wiretapper with access to this capability can effectively draw a loop remotely on any subscriber being serviced by that exchange with no physical interference or human intervention. Tabulations of numbers called, both outgoing and incoming, can be made secretly without subscribers' permission, for legitimate and illegitimate purposes, and skulduggery other than mere wiretapping is also possible.

Of course, wiretapping by a conventional drawn loop is also still possible; there are still distribution frames through which individual subscribers' lines are brought to the system and on which answering services can draw their loops. Clearly, the vulnerability and risk to privacy of ESS systems are enormously greater than in conventional telephone switching: a new era has begun for the wiretapping industry. We know of no additional safeguards built into ESS systems — hardware, software, or administration — and no regulatory or legislative body in the country is even considering that they be required.

The *Wall Street Journal*, for example, in reporting that the FBI and the state of New Jersey both use "more sophisticated equipment and have a much closer working relationship with the telephone companies than do New York police" (*October 5, 1973*), quoted a New Jersey assistant prosecutor: "We use a system where you can effectively sit in your home and monitor any phone in the country. You'll hear everything that transpires over that number. We have to pay (New Jersey) Bell Telephone a rental fee."

The New Jersey prosecutor's statement in this case may not be true at all — there is no simple way of knowing. The telephone company tends to be like the locksmith who assures you that you have the

only key to the lock he sells you. Samuel Dash (in *Eavesdroppers*) suggests that "most of the private wiretapping done in the world is done in the city of New York." In the same book, District Attorney Eugene Gold of Brooklyn was quoted as admitting that "there is probably a good deal of illegal wiretapping in New York. In my judgment, the vast majority of it is done by private firms or private businesses."

Whatever the locale, the general effect of this new technology is to widen the gap between the communications elite and the public. Most people can easily — almost instinctively — understand a cord patchboard, in which an operator sits and plugs people's wires in where lights shine. The mechanical switching in a central office operates with exactly the same effect and at least in principle is easily mastered. But few understand a computer program that does the same thing in vastly more complex and comprehensive ways. The technical qualifications needed to understand, let alone manipulate, any part of the telephone system are now vastly greater.

This means that the responsibility of the regulatory agencies to protect us is becoming far more urgent and requires far more sophisticated expertise.

Interference and Industrial Espionage

We have mostly discussed clandestine overhearing of communications messages. But forms of wiretapping leading to clandestine disruptions and dirty tricks are clearly feasible. These take the form of "technical difficulties" deliberately introduced onto some telephone lines. Making even firm guesses about the extent to which such practices occur is remarkably difficult, for the evidence is primarily anecdoctal and speculative; but we can make at least a partial list of what can be done:

☐ Deliberate misrouting — outgoing and incoming calls can be shunted to the wrong numbers.

☐ Introducing false busy signals to outgoing or incoming dialers.

☐ Creation of "phantom ringing," to persuade the caller that the called telephone is ringing when it is not. (The ringing sound the caller hears is not related to the actual ringing; it is generated within the local exchange.)

Other possibilities for disrupting communications will occur to the thoughtful. Some of these techniques have been feasible for some time in electromechanical exchanges, especially with the cooperation of telephone company personnel; but many are clearly more feasible as computer technology is integrated with telecommunications.

Although people may feel that the telephone hardware sometimes plays spiteful tricks which must involve human intervention, most of the harrassment dealt out through the telephone is probably just imagined. However, some of the harrassment may be real. The problem is that we do not know how much; nor, as with more conventional wiretapping, is there any simple way to find out. That is so especially because of the lack of support by telephone companies to those investigating persistent service irregularities.

The Fundamental Question: *Quis Custodiet Custodies?*

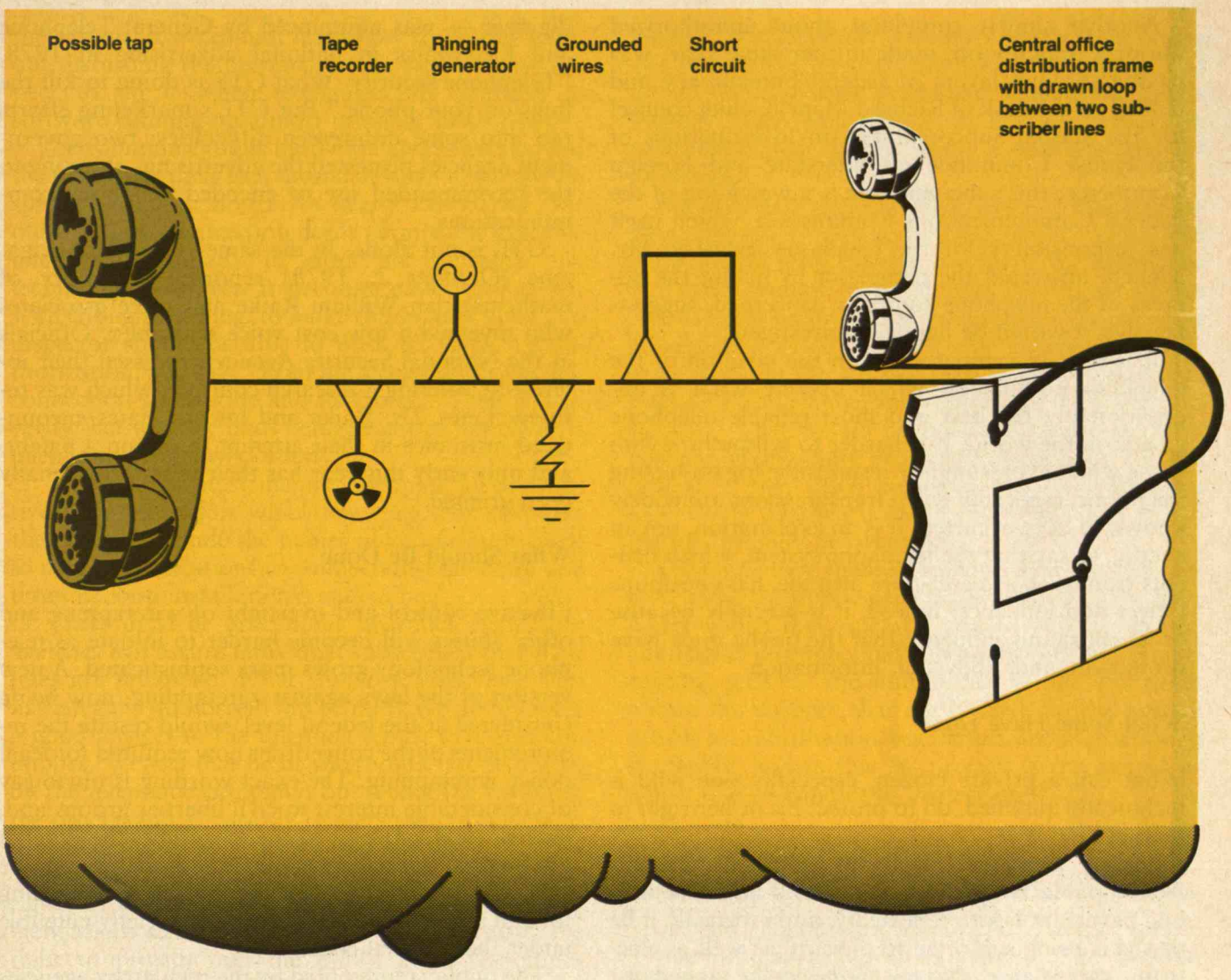
In the original Communications Act of 1934, wiretapping was flatly forbidden; nothing was said about the possibility of court orders permitting eavesdropping. The Supreme Court first held wiretapping permissible, subject to warrant requirements of the Fourth Amendment covering unreasonable searches, in 1967; the following year a federal statute set up procedures for obtaining warrants. Today anyone who wants legally to wiretap a telephone must have court authorization.

It is doubtful that a citizen subscriber can be legally tapped under the Constitution unless there is evidence (probable cause) connecting him or her directly to a crime. However, the police have little difficulty obtaining court orders permitting wiretapping in legitimate investigations of such crimes as commerce in drugs or stolen goods. It is difficult to say what ought to be done about corrupt police forces — clearly some are corrupt — who undertake illegitimate wiretapping, except that their practices and subterfuges should be corrected. Noncriminal cases involving national security, such as those that have made the headlines in recent years, are equally hard to evaluate.

Given that the privacy of the telephone can easily be breached and that the integrity of voice or data communications cannot easily be guaranteed, what should be the proper role of the government in protecting us? How should the Federal Communications Commission and the various state public utilities commissions regulate the telephone industry with respect to wiretapping?

Currently, especially regarding drawn loops, there is almost no control whatsoever by regulatory bodies. If the police find an illegal wiretap in the

Though this article concentrates mainly on techniques for eavesdropping on telephone conversations that users assume are private, other forms of skulduggery — "technical difficulties" deliberately introduced — are also possible. The diagram illustrates but a few of the possibilities: false ringing or busy signals, "dead" circuits, and intermittent short circuits to disrupt ongoing conversations. Despite this wide range for possible skulduggery, the authors note that "most of the imagined harassment dealt out through the telephone is probably just that — imagined."



course of investigating something else, they will act, but a complaint by a subscriber who suspects that his/her line may be tapped is referred only to the telephone company. The telephone company can inspect a subscriber's line and may do so on formal request, but there is no independent way of verifying what the telephone company finds or reports.

Furthermore, the telephone company is the primary party to any investigation of itself. In Massachusetts, for example, any security investigation by the Department of Public Utilities has to be undertaken in conjunction with the New England Telephone and Telegraph Co. The department feels that it lacks the necessary expertise, and entry into a telephone central office can be made only with permission; the regulatory authority seldom exercises any legal right of entry and inspection it may have.

The victim always has difficulty finding out what happened. In 1974 Morton H. Halperin, a former member of the National Security Council, filed a civil suit against President Richard M. Nixon and Secretary of State Henry A. Kissinger charging illegal electronic surveillance, including a drawn loop supplied by the telephone company at a central exchange; the depositions provided in court by three telephone company employees seem to confirm this.

In the same year, the *New York Times* quoted John deButts, then chairman of the American Telephone and Telegraph Co. (*May 18*): "Telephone companies never actively participate in government wiretapping activities. . . . We just show them what box or line they want and let them do the rest."

Another similar complaint about unauthorized use of a drawn loop, made in that same year, was passed through layers of federal bureaucracy and landed on the desk of Richard Manelli, chief counsel for the Special Subcommittee on Investigations of the House Committee on Interstate and Foreign Commerce; this subcommittee is a watchdog of the Federal Communications Commission, which itself has responsibility for the telephone industry. Mr. Manelli answered the complaint by giving the address of the telephone company concerned, suggesting that it would be happy to investigate.

It is easy to sympathize with the position of the telephone companies, which operate what is unquestionably the best and most reliable telephone system in the world. It is harder to sympathize with those who are presumably responsible for protecting the public, especially when transgressions are widely known to have occurred. It is an explanation, not an excuse, to say that the telephone system, which benefits from such a *laissez-faire* attitude, has enormous power and influence. Indeed, it is precisely because of its enormous influence that the public must have protection, and, above all, information.

What Some Have Done

What can a private citizen, especially one who is technically qualified, do to protect his or her right to privacy?

Clearly, a private citizen can make sensitive calls from a public telephone booth. But if he or she uses one particular booth repeatedly, and especially if he or she is being subjected to physical as well as electronic surveillance, that telephone can be tapped just like any other.

One possible technical defense was adopted in 1973 by Richard Locke, president of Teleserve, a Saugus, Mass., company providing remote car telephones. He arranged to fit to each of his customers' interconnecting lines a device to detect the drop in capacitance that occurs during the first ten seconds after the activation of a drawn loop. But that solution is not very good: the reliability of such devices cannot be ascertained, and making the system immune to such alarms is probably not technologically difficult.

Some private citizens, lacking the expertise to rig drawn loop alarms and not wishing to conduct all their business from sundry public telephone booths, have been intrigued by systems to encode and decode messages. One such device — a voice signal digitizer — was announced by General Telephone and Electronics in national advertising in 1978. "Telephone security. What GTE is doing to kill the bugs on your phone." But GTE's marketing efforts ran into some unforeseen difficulties: two government agencies protested the advertising, objecting to the recommended use of encoded telephone communications.

GTE is not alone. In the same year, *Time* magazine (*October 2, 1978*) reported the story of mathematician William Raike and three associates who invented a low-cost voice scrambler. Officials at the National Security Agency expressed their interest by offering a research contract, which was refused. Later, Dr. Raike and his associates encountered resistance in their attempt to obtain a patent, and only early this year has their application finally been granted.

What Should Be Done

Effective control and oversight of wiretapping and other abuses will become harder to initiate as telephone technology grows more sophisticated. A new version of the laws against wiretapping, now being considered at the federal level, would restate the requirements of the court order now required for legal police wiretapping. The exact wording is obviously of considerable interest to civil liberties groups and, indeed, to all citizens. In the meantime, the Foreign Intelligence Surveillance Act (1978) has given the U.S. government greater liberty in wiretapping foreign agents and U.S. citizens not strictly culpable under the criminal codes.

The public, represented by the regulatory agencies (chiefly the FCC and the state public utility commissions), must be able to find out what is going on within the telephone system *and must be able to verify it*. Imagine a public accountant auditing accounts without being able to make sure that the money is actually there! The requirements that we envision are these:

☐ Telephone companies must be required to keep records of all monitoring loops and attachments, including those for their own administrative purposes.

☐ These records must not be alterable except with additions; that is, every change must leave an audit trail.

☐ The records must be verifiable: that is, the regulatory agencies must be able to inspect the records and make sure that they describe the actual state of

the system. If we cannot learn how to do this without disturbing the current system, how can we expect to do it when exchanges are reduced to software running on almost invisibly small chips?

Telecommunications hardware and software, and the records of their use, should be open to proper inspection without notice. In nearly every state, the public utility commission needs permission from the telephone company to enter an exchange. As technology advances, it becomes easier and easier, with enough warning, to make things look good. An inspector should be able to walk in, show his authorization, and say: "Print me a copy of the current connection subroutine and its tables." Then he can verify that what he finds being recorded matches the telephone company's orders.

☐ The records must include adequate administrative data to support what they state. For example, they should include the names of people authorized to make modifications to connections, the dates and times of loop installations, and so on.

☐ There must be procedures by which regulatory agencies can assure individual subscribers that their lines are untapped. What should a subscriber who has a legally authorized tap be told? We do not have a good answer to the dilemma which that question implies. We feel that he or she should not be lied to by the telephone company; but telling the truth, on the other hand, obviously renders the tap useless to the law enforcement agency that sought it.

Increased public awareness of the constitutional rights of privacy may make some of these recommendations easier to implement. But, of course, the right to privacy and the public good sometimes conflict. Nobody would claim for every person the right to know whether another person has a connection on his or her telephone lines, but people as a whole have the right to know how many telephones have connections not ordered by the subscriber, and they have the right to be effectively assured that those connections are legal and proper. That is certainly not the case now.

The Future Need Not Be Like the Past

It is clear that new technology favors intruders; privacy will be increasingly hard to maintain without real governmental commitment to effective control. But before we condemn the new technology that seems increasingly to jeopardize privacy, we must remember that the same technology conveys extremely useful power as well. Touch-tone telephones, for example, are enormously timesaving and convenient, and they are the key to a number of useful services such as personal electronic funds transfer. Such enlargement of citizens' choices in conducting their affairs seems a desirable goal of technology.

But with such advances must come an increasingly alert, informed, and demanding public. More and more people must become aware of the anomalies that can be caused by espionage. The horror stories that are now oddities to be swept under the rug must be regarded as deviations to be corrected. People must abandon the attitude that "it may be true, but it doesn't concern me, and I don't care if my phone is tapped." That is said by people who are fairly, if perhaps falsely, sure that their telephones are *not* tapped. If they discovered that their conversations *were* being overheard and transcribed, they would almost certainly be outraged.

The regulatory agencies respond to what they perceive to be the public need (as expressed by the laws under which they operate) and to public outcries. Legislators respond chiefly to public outcries. An accepting, passive, and uninformed public will never obtain the changes that are needed. So the present need is for information, regulation, and inspection. If the public knows that its privacy is threatened — and it is — it can act to protect itself. ☐

Further Reading

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Oliver Selfridge is a computer scientist on the staff of Bolt, Beranek and Newman, Inc., of Cambridge. Following graduation from M.I.T. in 1945 (mathematics), he taught at the Institute for three years and was a staff member at Lincoln Laboratory for 20 years. **Robert T. Schwartz** is technical director of the Northeast Telephone Corp., a telephone interconnect company in Boston. He has had extensive experience in voice and data telephone communications since graduating in electrical engineering from M.I.T. (S.B. 1958), and he is a registered professional engineer in Massachusetts.

This article results largely from the efforts of the American Privacy Foundation, a nonprofit organization dedicated to educating the public to the need for verifying and assuring the security and integrity of telephone communications. Queries by the readership are invited (to P.O. Box 203, Weston, MA 02193).

Reducing Occupational Health Risks: Uncertain Effects and Unstated Benefits

by John Mendeloff

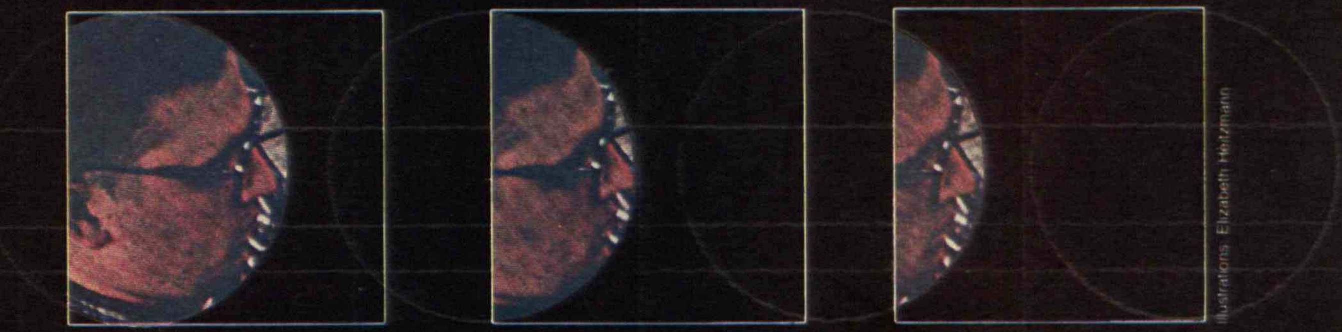
Regulators face increasing pressure both to protect workers and to justify the costs of regulation. Will we soon have to determine just how much a life is worth?

Economists' attempts to place a specific monetary value on prolonging a life garner little support, even among people who acknowledge that some standard is needed to allocate funds rationally among risk-reduction programs. Most people respond as if they were modern theologians confronted by efforts to calculate the number of angels who can dance on the head of a pin: first, there is puzzled amusement; then, if the attempt is serious and persistent, exasperation and anger.

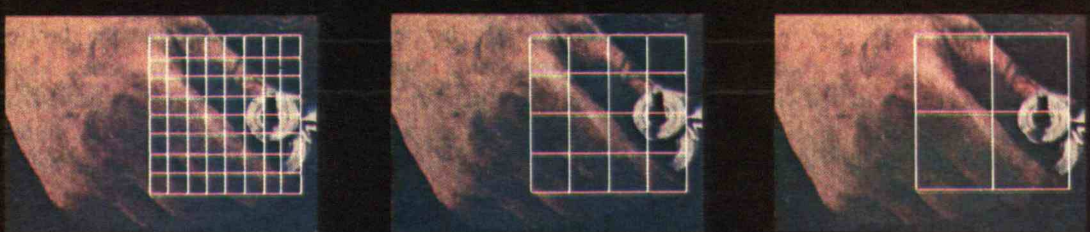
Officials of the Occupational Safety and Health Administration (OSHA) have frequently asserted that they will never "trade off lives for dollars," but they invariably add that "as responsible regulators, we must consider costs." The inconsistency of this position is matched by its popularity, for politicians and business and labor leaders usually endorse the same paradox. The result of this surprising consensus has been that, of all the health and safety regulators, OSHA has taken the strongest stand against estimating risks and making trade-offs.

In 1980 the Supreme Court will decide whether OSHA must make quantitative estimates of the health effects of its standards and weigh them against the costs to see if the balance is reasonable. The decision will come in a review of a fifth circuit court ruling that invalidated OSHA's standard for benzene (a likely cause of leukemia) because it failed to make such estimates.

Although the Supreme Court will probably not seriously curtail OSHA's discretion in setting standards, a more persistent challenge to OSHA comes from top administration economists on the Regulatory Analysis Review Group (RARG) and its staff from the Council on Wage and Price Stability (COWPS). Concerned that regulations may be achieving small benefits at excessive cost, they have sought White House review of some OSHA decisions. In June 1978, the president allowed OSHA to promulgate the cotton dust standard it had developed only after it had reduced the cost of the original proposal 75 percent. For the first time, OSHA followed RARG's advice to loosen exposure levels in those parts of the industry where the costs of reduc-



Illustrations Elizabeth Heitzmann



tion per exposed worker were especially high.

The conflict between economists and health regulators raises several critical issues. Does the call to quantify health effects — in terms of number of illnesses, deaths, and years of life lost — make sense in view of scanty data and undeveloped theories? How do we decide which risk-reduction measures are worthwhile? Specifically, how should we value the various effects on health and life of hazardous materials? Answers to these questions become increasingly important as scientific advances improve our ability to detect new hazards and the political process generates increasing demands to control them.

While many regulatory agencies are concerned with these issues, they currently have special meaning to OSHA. In 1977, seven years after its establishment, OSHA had set only four standards in the health field (involving asbestos, vinyl chloride, 14 carcinogens, and coke-oven emissions). Labor union leaders castigated OSHA for acting slowly in the face of thousands of potential hazards. OSHA responded by recently adopting a proposal for a generic carcinogen standard that would provide a mechanism for quicker action. During 1978, while that generic proposal was still under review, OSHA promulgated six more new standards. The figures cited in OSHA documents indicate that the current value of the costs of meeting those six standards could be as much as $7 billion. Even if the true figure is one-half this amount (firms have an incentive to overestimate compliance cost figures), the numbers are impressive enough to ask what society is getting for the money.

OSHA's approach to standard-setting can be examined by comparing its recommendations with those of the National Institute of Occupational Safety and Health (NIOSH) (*see table on p. 75*). Although the number of OSHA standards is small, we can include hazards for which OSHA has made a proposal but has not yet set a final standard. Because the NIOSH role is universally agreed to exclude economic considerations, a comparison of NIOSH and OSHA proposals gives a crude indication of OSHA's adherence to a pure health criterion.

OSHA Adopts Highly Protective Standards

The majority of standards deal with carcinogenic hazards; lead and cotton dust are the only clear exceptions. The recommendations of the two agencies are usually similar, or they differ only because of purely technical factors. One major exception is arsenic, where OSHA rejected stricter proposals primarily because they would have required closing a smelter that employed 1,000 workers and was the only domestic producer of arsenic trioxide. Another exception is noise, where former OSHA director John Stender overrode a staff recommendation to accept NIOSH's costly 85-decibel proposal. In fact, because full enforcement of even the 90-decibel level is estimated to cost over $10 billion, industry has persuaded OSHA to delay any decision until more research is carried out. Not apparent from the table is OSHA's total failure to respond to NIOSH proposals to regulate hazards due to heat stress and ultraviolet radiation. These two probably ranked low on OSHA's priority list partly because they involved major costs but were mundane hazards that affected only a tiny proportion of the workers exposed to them. Another factor may have been a reluctance to tangle with agricultural groups, who were already spearheading the anti-OSHA movement.

Thus, OSHA has been neither immune to political pressures nor totally insensitive to economic concerns. Nevertheless, the most striking fact is its support of strict protection. The extensive agreement of OSHA and NIOSH is not surprising when we consider that, as in its recent policy statement on carcinogens, OSHA requires all exposures to be reduced to the "lowest feasible level." OSHA has steadfastly maintained that a standard is feasible if it is technically possible to achieve and it is "within the financial capability of the industry" or not "overly burdensome." By these criteria, costs need hardly be considered as long as the firms affected are sufficiently large or profitable or the bulk of the costs can be passed on to consumers. In more political terms, cost impacts must not be dramatically visible; no major plant shutdowns or loss of jobs should be attributable to the standard. Almost any effort can be demanded from the major petrochemical firms, who are the group most affected by OSHA's regulation of toxics.

Estimating Health Effects

Of course, OSHA must present evidence that its regulations will have benefits. For carcinogens, the likelihood of cancer in humans is assumed to decline continuously as the dose decreases to zero. Most animal and human studies of carcinogens show that effects do decline as the dose is reduced, but deter-

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Estimating Costs per Life Saved

How believable are estimates of costs to industry per life saved? The quality of the underlying evidence varies, but some insight into the estimating process can be gleaned from a case study of acrylonitrile (AN) regulations.

To determine the dose-response curve for acrylonitrile, COWPS relied wholly on the preliminary results of an epidemiological study conducted by DuPont focusing on 470 males who worked at its Camden, S.C. plant from 1950 to 1955. For workers exposed between 1950 and 1952, eight cancer deaths had occurred through 1975 as opposed to four deaths expected — a difference that was just statistically significant.

COWPS estimated that AN exposures for the DuPont workers had averaged 20 ppm, a figure taken not from DuPont (which remained silent on this issue) but from Monsanto, which based the figure on its assessment of industry practices at the time. COWPS stated that it would use what it considered conservative assumptions, such as a 20-year latency period rather than shorter ones. With that latency period, only exposure between 1950 and 1955 became relevant. The average number of years of exposure given the 20-year latency model is 3.75. Dividing four excess deaths by 470 employees and then by 3.75 years gives an excess mortality risk from cancer of .00227 per person per year of exposure.

OSHA's consultants stated that 3,400 workers were exposed to AN levels between 2 and 20 ppm. Assuming that the dose-response curve had no threshold, COWPS calculated that reducing exposures to the lower figures (a 90 percent reduction) would also reduce excess deaths among the 3,400 workers by 90 percent — a reduction of seven deaths a year ($.00227 \times 3400 = 8 \times 90\% = 7$).

Using estimates obtained from industry that the costs of attaining a 2.0 ppm standard would be about $25 million a year, COWPS calculated a cost per fatality reduction of $3.5 million. Similar procedures showed the cost of going from a 2.0 ppm standard to a 1.0 ppm standard would be $29 million for each additional cancer death averted; and from 1.0 ppm to 0.2 ppm, $169 million for each additional cancer death prevented.

OSHA emphasized that the actual exposures of DuPont workers were unknown. It suggested, however, that 10 ppm exposure levels would be a more reasonable assumption than 20 ppm. This change would cut the cost per reduced fatality in half — down to $1.75 million for the 2.0 ppm level and down to $85 million for the 0.2 ppm level. However, many firms had already reduced exposures to the 2 ppm range for some operations, which reduces the expected improvement in health and hence increases the cost per cancer death averted.

Other factors — for example, overestimates of compliance costs or underestimates of the average latency period — could mean that estimates of the cost per cancer fatality averted are too high. These variables inject uncertainties into COWPS's attempt to use the DuPont study to estimate health effects (*see table above*). Some variables, such as the absence of smoking histories and the failure to trace all workers, probably don't create major biases. OSHA concluded that "while the actual estimation of the number of cancers to be prevented is highly uncertain, the evidence indicates that the number is likely to be appreciable." No hint as to the meaning of "appreciable" was given, and OSHA stated that it had found that further attempts at quantification would not help standard-setters.

Factors leading to overestimates of deaths prevented	Factors with uncertain impact	Factors leading to underestimates of deaths prevented
1. COWPS assumed a linear dose-response curve with no threshold.	1. Exposure levels from 1950 to 1955 may have been higher or lower than 20 ppm.	1. Not all exposed workers were traced.
2. Many facilities are already at or near 2 ppm exposure levels.	2. The average latency period may be longer or shorter than 20 years.	
	3. People in the sample may have smoked more or less than other DuPont workers.	
	4. Because of sampling error, the number of excess deaths could be larger or smaller than 4.	

Sources of uncertainty in COWPS's attempt to estimate the number of occupational cancer deaths prevented by OSHA's acrylonitrile standard.

Ironically, in light of this conclusion, there is some circumstantial evidence suggesting that COWPS's quantifications of risk may have influenced OSHA to stick with the 2 ppm permissable exposure level (PEL) required by the emergency standard rather than go to the alternative 1 ppm or 0.2 ppm PEL.

Companies had often before protested that compliance with OSHA's proposals was impossible. Indeed, OSHA often adopted standards that its own consultants considered technologically infeasible. OSHA justified these standards on the grounds that they were "technology forcing," and often acknowledged that not all work sites or operations could attain compliance with the standards.

It was therefore startling to find Dow Chemical — one of the major firms in the industry — announce that both the 1.0 ppm and the 0.2 ppm PELs were technologically attainable. Monsanto concurred on the 1.0 ppm PEL. However, in light of OSHA's past performance, it is hard to accept the claim that the grounds for the choice were purely technological. What remains unclear is whether OSHA leaders agreed with parts of COWPS's position (but were unwilling to express their concern with costs), or whether they were responding to the potential threat that RARG would take the issue to the president as it had done with the cotton dust standard. — *John Mendeloff*

The Limits of Cost-Benefit Analysis in Regulatory Decisions

by Nicholas A. Ashford

Cost-benefit analysis can be a useful tool, but some regulatory reformers would have us apply it as an indiscriminate, decision-making *rule*. I would like to offer some words of caution — on methodological flaws and on possible political misuse of the results — that may be summarized as follows:

☐ There are important differences between economic regulation and environmental, health, or safety regulation that must not be overlooked.

☐ Costs are easier to express than benefits, but their quantifiability makes them no more certain or reliable.

☐ Benefits include improved quality of life and good health as well as positive economic side-effects, but they defy accurate estimation and their recipients are not a well-organized lobbying group.

☐ The comparison of costs and benefits is beset by serious methodological difficulties and requires the analyst to make value-laden assumptions; yet cost-benefit analysis appears, deceptively, to be a neutral technique.

☐ Insistence on cost-benefit decision rules and other regulatory "reform" efforts may be undemocratic attempts to reorient legislative mandates.

Crucial Distinctions

Economic regulation seeks to improve the workings of the market by encouraging competition, economic efficiency, and a diversity of goods and services. Regulation addresses itself to this goal by attempting to ensure that the price mechanism operates efficiently to properly allocate goods and services among economic sectors and between producers and consumers. Economic regulation, therefore, properly carried out, is expected to reduce prices.

Health, safety, and environmental regulation, on the other hand, attempts to ameliorate the adverse consequences of market activities — and technology in general — by reducing the attendant social costs. This regulation attempts to internalize the social costs of production by ensuring that the prices of goods and services reflect true costs to the society. Although prices can be expected to go up in response, Charles Schultze (in his now-famous work with Alan Kneese entitled *Pollution, Prices, and Public Policy*) has cautioned us not to regard as inflationary those price increases that internalize social costs.

The assumption that all price increases are inflationary (indeed, inflation was so defined by an early executive order of Gerald Ford) ignores the crucial distinction between economic and environmental regulation. With economic regulation, associated price increases may well be inflationary and an indication that government efforts need to be reexamined. But with environmental regulation, price increases may be a measure of success. Environmental regulation is not really an instrument of economic policy; it is an instrument of *social* policy concerned with the nature and distribution of the effects of industrial activity. Therefore, environmental regulation cannot be judged by economic criteria alone.

Even if such criteria are (inappropriately) used,

inflation is still a phony issue in the national debate over environmental, health, and safety regulation. Actual estimates of the effects of such regulation on the Consumer Price Index — by several groups, including the president's Council on Wage and Price Stability and the Council on Environmental Quality — place the effect at well below 1 percent in a time of double-digit inflation.

Inflated Numbers

Because the costs of complying with regulation can be easily monetized, it is often assumed that they are reliable estimates of true costs. But in many instances the costs are not only uncertain, they are also unreliable. Agencies depend to a large extent upon industry data to derive estimates of compliance costs, and I do not believe I am being too unkind in questioning the bias of those estimates. The regulatory agencies generally do not have access to information, especially on alternative products and processes, that enables them to come up with the best estimates of compliance costs.

Compliance cost estimates often fail to take into account three crucial issues:

☐ Economies of scale are inevitably realized by increased production of compliance-related technology.

☐ A regulated industrial segment is able to learn, over time, to comply more cost-effectively — management scientists call this the "learning curve."

☐ Compliance costs based on present technological capabilities ignore the important benefits, both to the regulated firm and the public, that come from technological innovation.

Environmental regulation has often been called "technology-forcing," so costs of compliance should not be based on static assumptions about an industry and its technology. Otherwise, a large overestimation will result, as in the case of the OSHA vinyl chloride standard. The actual (and minimal) economic impacts were in stark contrast to ominous preregulation predictions.

Understated or Unstated Benefits

The "science" (or perhaps the "art") of estimating numbers of prevented cancer cases, chronic disease cases, or even injuries is in its infancy. Because of the accepted view of cancer causation, many health professionals believe there is no safe exposure to a carcinogen. Safe levels for chronic toxins (which are not carcinogens) are often derived from either acute human exposures or high-dose animal experiments, and techniques for extrapolating to lower doses for chronic human exposure are imperfect. Therefore, benefit calculations for a particular maximum exposure level (allowed under a specific regulation) are often not very meaningful.

Theories of accident prediction do not serve us much better. We scarcely need reminding of the unanticipated risk that attended the incident at Three Mile Island, or the failure to predict design defects in the DC-10.

Both costs and benefits of regulation are beset by uncertainty; however, the uncertainty surrounding the benefit calculations is usually much larger. It is fair to say that the state-of-the-art in benefit estimation is much less developed than the methodologies for calculating compliance costs. In addition, there is no organized interest group that systematically pursues benefit estimations in the same way that compliance costs are researched. And the tendency by analysts to rely on hard numbers — softer numbers are harder to believe — places the estimation of benefits on insecure ground.

It must also be realized that the benefits derived from direct regulation are only a part of the benefits of the regulatory process. Indirect, or *leveraged*, benefits are derived from the pressure of regulation to induce industry to innovate — to deal preventively with previously unregulated hazards and to find ways to meet the public's need for a cleaner, healthier environment while maintaining industrial capacity. Put another way, the positive side-effects accompanying regulation need to be included in a complete assessment of the effectiveness of the regulatory agency's strategies.

Comparing Apples and Oranges

Even if we could accurately estimate the amount of disease or injury prevented by regulation, and the costs of doing so, two difficult tasks remain:

☐ Monetizing health benefits that may accrue far into the future (or even monetizing current accident-prevention benefits); and

☐ Comparing those benefits to current compliance costs.

A human life or a lost limb does not have an established market value. Payments to workers to assume risky occupations prior to being injured (*ex ante* valuations) are different from the values placed on the injured workers by their families after the injuries have occurred (*ex post* valuations). Which valuation is correct? The work of Fischhoff, Kasperson, Kunreuther, and others amply demonstrates the inability of people and firms to consistently evaluate long-term, low-probability risks. These characteristics leave market valuation of the benefits of regulation in great doubt.

There is another crucial problem with regard to valuation. Economic efficiency reflects the maintenance of current economic arrangements, and it is naive to talk about workers who sell their wages off for their health as if the transaction took place in an unconstrained market. A worker does not have a large bundle of economic goods, and this affects his or her selling price. If you think it is unfair for poor people to sell their wages off more cheaply than wealthy people, then you do not like the working of the market. If you do not care, then you are willing to allow the working of the market mechanism. It inevitably comes down to the fundamental issue of the distribution of wealth.

Some analysts still insist on expressing health, safety, and environmental benefits in monetary terms, although this practice is changing. The successor to evaluating a change of net social welfare in dollars is the benefit-to-cost ratio — e.g., the number of fatalities prevented per dollar expended. The problem with this index is that it can never really be applied. The benefits of regulation include deaths prevented, diseases and injuries prevented, pain and suffering prevented, hospital costs prevented, and so on. The benefit part of the ratio is composed of many elements of different character — how do we decide, for example, how many serious injuries are equivalent to one death? In addition, how do we properly "discount" the costs and benefits that accrue,

each differently, over time?

The present value of the net effects of any given regulation, or the *ranking* of the effects of alternative regulatory regimes, can change markedly depending upon the discount rate used in the cost-benefit calculation. For example, using a discount rate of zero for future health benefits (i.e., not discounting future health benefits) may make a regulatory choice tenable, while using a discount rate for health benefits comparable to the discount rate for capital expenditures may show a proposal to be undesirable. Further, since the consequences of many regulatory actions may be to impose compliance costs today in order to bring about health benefits far into the future, the choice of discount rate can make one regulatory option look better or worse than an alternative. Since there is no consensus on what that rate should be, the policymaker's preference for a particular regulatory option can be hidden in the choice of a discount rate.

An even more serious limitation of a simple comparison of costs and benefits is that it ignores equity implications — costs and benefits are often borne by different groups of people. Thus, the aggregation of costs and benefits is value-laden — it is a political decision, conscious or unconscious, to ignore equity.

Finally, the comparison of costs and benefits of a regulation must in turn be compared against what might happen in the absence of that regulation. If we estimate the benefits and costs of adopting a safety standard for a consumer product, for example, we must ask whether the manufacturer could make the product somewhat safer in the absence of regulation — in response to product liability lawsuits, for example. It might not be correct, therefore, to attribute to regulation either all the costs expended or all the benefits conferred.

Whose Mandate?

There are a number of different benchmarks that the regulatory decision maker might use to arrive at a particular strategy and hence be called on to defend. They include economic efficiency, cost-effectiveness, health-effectiveness, distribution consequences (equity), and specific mandates embodied in various pieces of legislation. In some legislation, the discretion on how to "balance" various considerations is broad; in others, it is more narrowly defined. In many instances, criticism of a particular decision to regulate is really a criticism of the balance struck by Congress in empowering an agency to act. Attacks on the FDA's ban of saccharin or on OSHA's standard for occupational exposure to benzene, for example, are really attacks on the legislative mandates. By asserting that a standard is not cost-effective or that it is too expensive, critics are attempting to force an evaluation of the proposed regulation against different benchmarks.

A more serious concern, however, is that assessment of an agency's economic impact, by groups such as the Council of Economic Advisors or the Council on Wage and Price Stability, may really be strategies to reorient various legislative mandates to their own point of view. It is certainly undemocratic, if not dangerous, for our society to let any one group of people — whether scientists, lawyers, or economists — set national priorities, and we must try to avoid such a "tyranny of experts."

There are no facile rules of thumb, no quick fixes, no simple indices of correctness in environmental regulation. A search for a facile decision rule — imposing upon the regulatory decision makers a requirement to undertake analyses that are overly quantitative and restrictive — would in reality *absolve* regulators from accountability rather than force them to articulate the hard choices. What can be expressed in a cost-benefit equation is only a small part of the picture. Efforts to improve regulatory decision making might best be focused on ensuring that government, workers, consumers, and industry have better access to information — on the nature and extent of health hazards, and on the technological capabilities of industries to respond to regulatory controls. □

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mining the threshold of toxicity is more complex. Many studies report exposure levels (for mice or men) at which no harmful effects are detected, but empirical work probably cannot conclusively determine whether thresholds exist.

Although in its cancer policy OSHA acknowledges that risk assessments may be useful, it has never done them, asserting that solid bases for making estimates don't exist. However, others have used the data OSHA gathered to suggest that the coke-oven standard would prevent workplace cancer deaths at a cost of anywhere from $500,000 to $150 million per death prevented. Richard Wilson estimated that OSHA's 1 ppb benzene standard would cost $300 million per death prevented. COWPS estimated that the 2 ppm acrylonitrile standard would cost $3.5 million per death prevented. A study of the asbestos standard adopted in 1972 suggested that the likely costs had been $250,000 or less for each death prevented.

What should we make of such estimates? In only six cases — cigarette smoking is the best-known example — has sufficient evidence been amassed to establish dose-response curves for human carcinogens. The arguments produced by COWPS on the acrylonitrile (AN) standard are more typical: evidence bearing on the relationship is just beginning to appear.

To highlight the differences between OSHA and COWPS, and thus the issues that regulators must confront, here is a hypothetical dialogue between OSHA and COWPS officials.

OSHA: A quick glance at the table on page 69 should suffice to show that the attempt to quantify health effects quickly degenerates into a sheer guessing game.

COWPS: Perhaps, but how does a confession of ignorance help us to make a decision about what exposure levels to permit? And don't tell me that we should keep exposures as low as "feasible"; that approach totally ignores the question of whether the health gains justify the costs.

OSHA: Well, "feasibility" *is* the criterion cited in the statute, but I agree it's vague. Maybe a more workable criterion is that OSHA should minimize the probability of catastrophic outcomes. Suppose, for example, that it seemed possible, although unlikely, that failing to lower the AN exposure level from 2 ppm to 1 ppm would result in 200 extra deaths a year. Even a small possibility of that outcome would justify the stricter standard.

COWPS: How small: one in a million, one in ten? You can't just ignore what the size of the probability is. And you can't ignore the costs.

OSHA: This is hypothetical, because you can't estimate the risks, but I would say that any terrible outcome with more than a 1 percent or maybe 5 percent probability of occurring should trigger the strictest standard.

COWPS: What do you mean by "terrible" and how did you arrive at those figures? I object to your adoption of such extreme risk aversion. Most people just aren't that pessimistic or traumatized by unlikely threats. But I want to get back to your equating great uncertainties with total ignorance. We're not totally ignorant. As in the case of AN, we do have a basis for estimates of risk. It's irresponsible to ignore the best available evidence.

OSHA: It's irresponsible to act as if the evidence allows greater precision than it does. Point estimates are deceiving. Almost every variable needs to be expressed as a distribution. You would need to conduct a sensitivity analysis to see how the answers vary as you choose different points in the distribution.

COWPS: Fine.

OSHA: Hold it! I should add that we really don't know what the distributions look like. Many probably look more like upside-down pie plates than bells, with broad plateaus where a wide range of figures are equally probable.

COWPS: But you're admitting that estimates can be made. For each variable, we can carry out the process you describe. For example, how much of a difference could cigarette smoking make in our calculation of the cost per life saved? Of course, since we don't know whether workers exposed to AN smoked more or less than other DuPont workers, the expected effect is zero. A recent study has shown that the smoking history of the sample generally has to be dramatically different from the population to significantly change the estimate of excess deaths. A dramatic difference seems unlikely. If there had been unusual rules forbidding smoking at these jobs, we probably would know about them. Thus the possible impact of smoking history on our estimate is probably small; perhaps there's a 20 percent chance that it could result in adding or subtracting one excess death to our estimate of four excess deaths. In this manner, we sketch a rough distribution. Multiplying these distributions will give us a final distribution of the probabilities of different numbers of excess deaths.

I grant that some of these results won't be worth

very much, but some will help us focus on what the crucial uncertainties are, and should guide efforts to develop better data and better tools for making estimates. After all, when we're talking about spending hundreds of millions of dollars for each regulation, the payoff from better estimates could be a bonanza.

OSHA: The problem with this whole exercise is that the computed estimates will cover such a wide range that they won't be useful. *At best*, you will proudly conclude there's a 50 percent chance that the cost per life saved is between $100 thousand and $6 million, with only a 10 percent chance that it is less than $20 thousand or more than $12 million. So what?

COWPS: I'll tell you "so what." We could conclude that, on this criterion, this standard is quite likely to be superior to one where there's a 50 percent chance that the cost per life saved is between $8 million and $20 million. But I don't think we will know how useful estimates will be until we start making them. And the more effort we devote, the better the estimates will become. Why don't you start trying before you judge the attempt a failure?

OSHA: You may recall that on one of our earliest standards, the economic impact consultant surveyed medical experts to derive an estimate of the health effects of different exposures to asbestos. The survey revealed a near consensus on what we now believe to be a substantial underestimate of the risks. The experts may not know the answers.

COWPS: But again, what is the alternative to relying upon the best available evidence?

OSHA: That sounds nice, but what does it mean in practice? For most hazards, we don't have any human evidence at all. Scanty as the evidence is on acrylonitrile, we have a flood of it compared with what we have in most cases.

COWPS: That's true if you look at the universe of toxic substances, but not if you look at the hazards that OSHA has actually addressed. Some evidence on human effects was usually available.

OSHA: But in the future that will usually not be the case.

COWPS: You may be right, but there will still be opportunities to use animal tests and short-term tests (for mutagenicity) to glean some insight about the cancer threat to humans. Almost without exception, substances known to cause human cancers also cause animal cancers, although the site of the tumors is not always the same. Moreover, in most of the six cases in which fairly solid estimates of dose-response curves for carcinogens in humans have been established, there is a rough correlation between potency in rodents and in people. Given the enormous range of biological potencies of carcinogens possible (over a millionfold), this rough correlation is quite significant.

OSHA: Your willingness to base policy upon a string of highly tenuous quantifications amazes me.

COWPS: No more than your disregard of the magnitude of health effects astonishes me.

Several points emerge from this all too plausible debate. COWPS's point estimates are misleading. When the uncertainties are acknowledged, policy implications will often be murkier than COWPS suggests. OSHA deserves criticism for failing to examine even what range of effects is plausible. Left implicit in the debate is the crucial fact that estimates of health effects have policy implications — how much are risk reductions worth? As estimates of health effects become more reliable, the pressures to value them will increase. Uncertainty undercuts the importance of valuation because if people can't agree about the health effects, then differences in the way they value those effects may have little meaning for the value of "lifesaving."

OSHA's leaders deny that useful quantitative estimates of health effects are possible because they do not want to confront the trade-offs that such estimates would explicitly present. COWPS's economists argue that useful estimates are possible partly because the contribution of economic analysis (and hence of COWPS) in the regulatory process would be diminished if the uncertainties were viewed as impenetrable.

By implying that solid estimates are available, COWPS indirectly seeks to create pressure for valuation. Yet COWPS has refrained from offering OSHA explicit guidance about when the cost per life saved becomes excessive. The council has even stated, somewhat disingenuously, that "OSHA should not expend efforts attempting to assign a dollar value to saving a life," despite its awareness that cost-effectiveness alone can't serve as a basis for making decisions because it does not tell us what level of risk reduction we should seek.

On political grounds, the COWPS strategy is easy to understand. Valuing reductions in fatality risks is controversial, especially in the occupational health field. Yet, in addition to the political concerns, valuation raises thorny ethical issues. Which of us wants to take responsibility for deciding whether some people will die from cancer? As a society, the

Below, left; OSHA's responses to exposure limits recommended by NIOSH. All exposures are for eight-hour, time-weighted averages. C = ceiling, an exposure that is not to be exceeded at any time. Asbestos is measured in fibers per cubic centimeter. Each recommendation for coke-oven emissions used a different indicator of harm: CTPV (coal tar pitch volatiles), respirable particles (benz (a) pyrene), and BSFTPM (benzene-soluble fraction of total particulate matter). All are measured in mg/m³.

	Recommended Exposure Limit		
Hazard	**NIOSH**	**OSHA Proposal**	**OSHA Promulgation**
Asbestos	5 now; 2 after 2 yrs	5; 2 in 4 yrs revised: .5	5; 2 in 4 yrs
14 Carcinogens	work practices	work practices	work practices
Vinyl chloride	work practices	no detectable level	1 ppm; c = 5
Coke-oven emissions	.2 CTPV	.3 respirable particles	.15 BSFTPM
Lead	.15 mg/m³ revised: < .15	.10 mg/m³	.05 mg/m³
Arsenic	.050 mg/m³ revised: .002	.004 mg/m³	.010 mg/m³
Benzene	1 ppm	1 ppm	1 ppm; c = 5
DBCP	none	1 ppb; c = 10	1 ppb
Cotton dust	.20 mg/m³ or less	.20 mg/m³ respirable dust in 7 yrs	.20 or .50 or .75 mg/m³ in different sectors in 4 yrs
Arcylonitrile	4 ppm	2 ppm	2 ppm
Beryllium	.001 mg/m³; c = .005	.001 mg/m³; c = .005	
Noise	85 decibels	90 decibels	
Tolvere	100 ppm; c = 200	100 ppm c = 200	
Trichlorethylene	100 ppm; c = 150	100 ppm; c = 150	
Sulfer dioxide	2 ppm	2 ppm; c = 10	
Ammonia	c = 50 ppm	c = 50 ppm	

Below right: The relationship of the strictness of governmental risk reductions to workers' knowledge about hazards and their abilities to act on that knowledge.

	Workers' knowledge about hazard	
Workers' ability to act on information about hazards	**Newly perceived hazard**	**Recognized hazard**
Low High mobility costs and/or low probability of compensation	Strict reductions in risk	Less-strict reductions in risk
High Low mobility costs and/or high probability of compensation	Less-strict reductions in risk	Least-strict reductions in risk

general distaste for "putting a price tag on life" may rationally justify "ignoring" costs. But we are willing to "ignore" costs only as long as they stay below some threshold.

Several surveys show that popular support for workplace safety and health regulation is strong, although a critic could ask whether people really understand what the costs and benefits are. An OSHA supporter might retort that if you asked people whether they would be willing to pay $.40 more for a $20 shirt to prevent early deaths among textile workers, they would overwhelmingly answer yes. Such a response does seem plausible, yet it raises an interesting question. Why haven't some textile companies tried to get a leg up on their competitors by claiming (truthfully or not) to have reduced risks, and collect higher prices from those consumers who are willing to pay? Are people unwilling to "put their money where their mouths are"? Perhaps only if everybody else does — an action that only government can require.

Despite this distaste for putting a monetary value on lifesaving, some government agencies explicitly do so. Several agencies within the Department of Transportation — the Federal Highway Administration (FHWA), the National Highway Traffic Safety Administration (NHTSA), and the Federal Aviation Administration (FAA) — make safety decisions using valuations of several hundred thousand dollars per death averted. A characteristic feature of these decisions is that because they potentially affect major portions of the population, the potential beneficiaries are essentially unidentifiable. Choices among highway safety projects are unlikely to raise strong feelings because people usually don't know which regulation would benefit them most. And because the probability that any particular individual would benefit is usually small, incentives for political action are limited. In contrast, although the precise victims can't be identified beforehand, OSHA often faces decisions affecting hundreds or thousands of workers at particular plants. Representatives of these workers will personally confront the standard-setters and present the issues in human terms, invoking the "trapped miner" image.

A second general characteristic of highway safety standards is that the risks being regulated are shared by the regulators themselves. They all drive cars and

ride in planes. We all realize that we take risks in these activities. When risks are not shared — as is typical of occupational cases — the decision maker's regulatory role becomes more paternalistic and tends toward greater protectiveness. Also, tax dollars directly finance expenditures for meeting safety regulations of the FHWA and the FAA. These agencies must decide which risk-reduction measures are worthwhile faced with limited budgetary resources and responsibilities that extend beyond safety.

NHTSA has faced unusual pressures to value the prevention of early death because the auto companies have been willing to present their own benefit-cost studies of the agency's proposals. In sharp contrast, firms have never publicly placed a value on reducing risks to workers. One reason surely is that as long as they are at the workplace, workers are under the authority of management in a way that consumers — who may or may not be willing to "buy safety" — are not. It could hardly soothe labor relations or the managers' own consciences to say that health measures were foregone because the marginal benefits fell short of the costs. Even if firms claimed that the measure of benefits is how much the *workers* value the safer environment, they would encounter withering skepticism about their ability and incentive to measure those costs correctly.

This does not mean that governmental action on occupational health will inevitably be highly protective — public regulation prior to OSHA has not been. The political and bureaucratic environment in which regulation occurs is crucial. The protective quality of OSHA's health standards can be attributed primarily to pressures from organized labor combined with the attention the issues have received among public interest groups and health professionals. The unions protect OSHA from congressional attack, while the Labor Department encourages health professionals to give worker protection the highest priority.

Our earlier discussion suggested that COWPS should be more willing to admit the uncertainties in estimating health effects and *also* more willing to guide OSHA about how to value them. But political constraints limit COWPS's options. The council has complained that OSHA's implicit valuations seem to be much higher than those used by other agencies and that, as a society, we could prevent more early deaths by reallocating our efforts so that the marginal cost per early death averted is the same in all programs. Critics of this view have protested that money originally targeted for reducing, say, AN-induced cancer deaths would not, in fact, be reallocated to saving other lives.

Both points are limited in their attempts to apply cost-effectiveness analysis too broadly and too crudely. There is no reason to believe that people value the prevention of an early death equally in all situations. But, precisely because people value many things besides risk reduction, the reallocation of funds to some other purpose is not necessarily bad. The issue is whether the value of risk reduction exceeds the value of what we have to give up to get it.

Equating Lives with Earnings

But aside from courting political hazards, attempts to assess the value of risk reduction have not and cannot produce unambiguous answers. The figures for the value of lifesaving used by the transportation agencies are derived from a "human capital" approach equating a loss of life with a loss of earnings. Except in a slave society, or one in which the maximization of GNP is accepted as the dominant societal goal, this procedure is clearly inappropriate. A more attractive approach is to ask how much the affected people would value a given risk reduction.

For collective decision making, however, we first need to clarify *whose* valuation should count. Some have suggested that only the individuals at risk should be counted. However, in a democratic society, it is hard to argue that popular opinion should be ignored. This is not to say that regulators should merely ratify whatever position has the most political support, but rather that they should ask themselves what sort of popular concerns hazards would arouse if people were aware of them. Even if all risk-reduction programs in the United States were publicly funded and chosen by a "minister of early death prevention," values of different reductions would still vary. The questions then become:

☐ What are the legitimate variables in valuing risk reductions?

☐ How much of a difference should each factor make?

☐ What is the base valuation from which these adjustments should be made?

An answer to the first question alone would not be very helpful; we would only be able to rank those few programs that differed on just one criterion. (If programs differed on two or more criteria, we wouldn't know which variation carried greater weight.) If we could agree on the answers to the second question as well, we would know *by how much*

the amounts we value a given risk reduction should differ, but not what the absolute level of the valuations should be. Answers to the first and third questions would enable us to say whether we should value a risk reduction in a program more or less than that base valuation, but we wouldn't know how much more or less.

No consensus exists about the factors that should influence how much we spend to reduce risks. Since social decisions should reflect the concerns of people at risk and those who care about them, we need a better understanding of attitudes toward different types of risk. The following list is intended to be suggestive:

☐ The first consideration should be the contribution a program makes to reducing *early* death and lifespan inequality. The fact that we never "save" lives but only prolong them is no mere semantic quibble. Preventing the accidental death of a 30-year-old is quite different from preventing a disease that would cause a death at age 70. Some survey evidence is available that shows most people are willing to give a higher priority to the prevention of a younger person's death.

☐ Pain, suffering, and disability should clearly be considered as well as death. Some injuries or diseases are more dreaded than others. Although concepts such as "quality-adjusted life year" have recently been developed to compare the health effects of different programs, they must be used with caution. Not only are interpersonal comparisons less acceptable in this context, but the procedure of valuing healthy years more than sick ones raises a competing principle — that, in some cases, an added *quantity* of years should compensate for lower *quality* years.

☐ The extent to which people voluntarily submit to risks clearly bears on whether government should intervene *at all* to reduce risks. However, once government has decided to intervene, the relevance of voluntariness to the choice of *how strictly* to regulate is less obvious.

Inescapable Risks

Skydivers and skiers voluntarily expose themselves to certain risks; in contrast, the threat posed to the ozone layer by fluorocarbons creates a potential hazard that no one can avoid. When people are well-informed about hazards and have substantial ability either to get away from them or to be compensated for accepting them, the case for government intervention falters. We can be relatively confident that the people involved feel the risk is worth taking. People who are uninformed or cannot move away may be forced to accept risks whose reduction they value highly.

The occupational health cases resemble air-pollution problems more than the ozone threat because workers are not compelled to stay at a particular job. However, the costs of mobility may be substantial, especially for senior workers. As long as the mobility costs outweigh the perceived health costs, they will stick with their jobs, tolerating higher risks than they would have initially chosen. Rather than allow losses due to either disease or mobility, government should require firms to reduce health losses, especially assuming that most of the costs will be passed on to consumers. The higher the mobility costs, the stricter the standard should be to reduce health losses to the level that workers would have initially accepted.

However, we should note that unlike the usual air-pollution case, occupational settings often allow those at risk to bargain for compensation. If workers were not aware of the hazard they faced — because they were poorly informed or because its toxicity had not been discovered — they should not be asked to pay for abating it (by accepting lower wages) when consumers and stockholders have benefitted at their expense. An alternative is to pay workers more to accept the newly announced risk. Where feasible, this alternative would often be the most efficient; however, it runs counter to the popular rationale for regulation, which is to protect workers who have little information and limited mobility — *not* to help workers get more money for taking risks.

But consider a situation where workers are organized, informed, and face low mobility costs. Suppose they decide that the level of risk from a known hazard should be lower. In this situation, the argument for highly protective government standards is weakest (*see table on p. 75*).

Even if different hazards could be clearly distinguished, we would still face the challenge of deciding how much variation in valuation these distinctions merited. For example, although we may agree that preventing a 30-year-old's accidental death deserves higher priority than adding a year to the life of a 70-year-old, unless we adopt a strict calculus of maximizing years of life added, it isn't evident that the former would take priority over adding 1 year to the lifespans of 40 elderly people. People do dread cancer, but how much more should we be willing to

spend to prevent a fatal lung cancer than a fatal heart attack? How much more protective should standards be when the workers at risk didn't know there was a hazard until they were "locked in" by seniority?

In a recent study, respondents presented with a list of 30 activities (e.g. police work, smoking, skiing, electricity generation) were asked to rate the magnitude of either the risks or the benefits on a 10-point scale. Holding perceived benefits constant, the level of acceptable risk was judged higher for old, voluntary activities with well-known and immediate consequences. Unfortunately, interpreting what these quantitative ratings mean in other contexts appears impossible. Perhaps future research should try to elicit people's responses to actual regulatory choices.

Ethical and Poltical Dilemmas

It may turn out, as I suspect, that determining *how much* variation in valuation of risks is justified will be the most difficult question to answer. An inability to set reasonable bounds on the variations increases the possibility that regulators will misuse their discretion. Consequently, it might be preferable to use a single valuation figure, recognizing that it is crude and imperfect, but still concluding that the costs of crudeness are less than the costs of untrammeled discretion. However, we might still choose the discretionary approach because simply ignoring these distinctions is distasteful on procedural grounds.

Whenever we must decide whether to help people in a group to which we do not belong, the choices have an obvious ethical dimension. The argument that we should consider only the willingness to pay of the people at risk is a political, not a methodological, position. Yet, the individual's valuation may provide the conceptual base from which variations can be considered.

To estimate the willingness of people at risk to pay, we can ask them. A problem with this direct approach is that people may overstate or understate their valuations depending on whether they think that they would have to bear the costs. Some studies have examined labor markets to see whether workers receive higher pay for more dangerous work. The findings are generally affirmative, although some figures cluster around $200 thousand to $300 thousand per extra death and others between $1.5 million and $3 million. For example, if, holding other factors constant, workers received an extra $1500 a year for each extra one-in-a-thousand annual risk of death, then the inference is that 1000 workers would accept $1.5 million less for jobs in which one fewer death occurred each year.

Because these studies are marred by a number of theoretical and methodological problems, including a lack of knowledge about how well workers understood the risks they faced, policy implications should be drawn cautiously. It is also important to remember that the mean age of workers sampled is usually the late thirties, and that the risks they perceive are mainly those of fatal accidents. Consequently, the results can provide only a baseline from which to start weighing other factors.

Further analyses of these issues are not likely to lead to the adoption of explicit policies on valuation, but they may clarify and change the thinking and choices of regulators. If regulators can be persuaded that the range of effects can be estimated and that discussion of valuation is not necessarily a mark of inhumanity, they will probably become more willing to look at the issue of cost-effectiveness. Or, they may be *pressured* to look at it. Pressure probably resulted in the concern for cost-effectiveness in setting the cotton dust and acrylonitrile standards. Although pressure on OSHA to quantify is desirable, ignoring or belittling the uncertainty is not. Such belittling diverts attention from the need to devise ways to reduce uncertainty and to decide how its presence should affect the choices we want regulators to make. □

Further Readings

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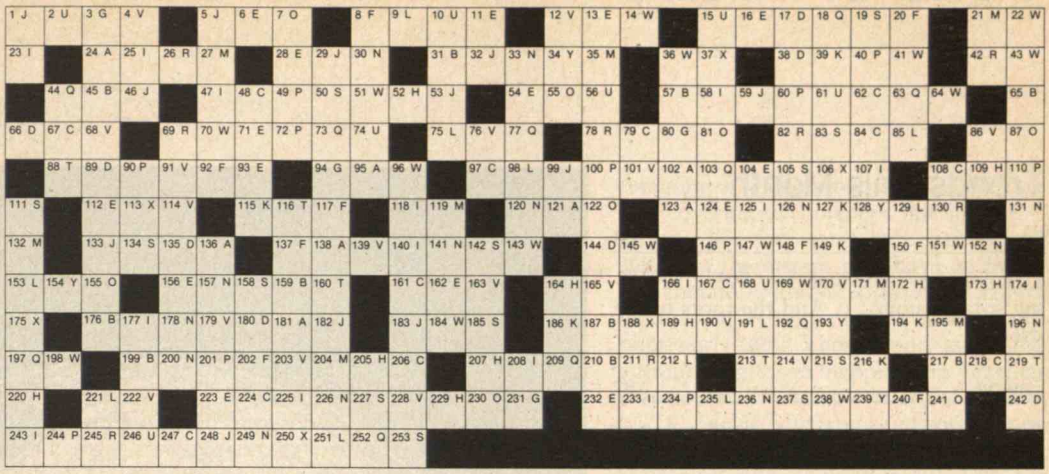
John Mendeloff teaches policy analysis at the University of California at San Diego and is the author of *Regulating Safety: An Economic and Political Analysis of Occupational Safety and Health Policy* (M.I.T. Press, 1979).

Drawing the Electric Fire



Complete the word definitions; then enter the appropriate letters in the diagram to complete a quotation from an article on early electricity. The first letters of the defined words give the author and title from which the quotation is taken. Black squares in the diagram indicate the ends of words; if there is no black square at the right end of the diagram, the word continues on the next line. A solution to this Tech-Crostic will be in the next issue of the Review, when another of Mr. Forsberg's puzzles will also appear. Readers are invited to comment — and to suggest favorite texts for future puzzles.

A. Soviet theoretician, 1888-1938, purged by Stalin
181 95 24 121 123 136 102 138

B. Character in Shaw's "Caesar and Cleopatra"
65 210 187 31 159 176 57 199 217
45

C. 4203-meter peak in the Swiss Alps
67 224 161 97 108 79 247 206 167
218 48 62 84

D. Orientation of an aircraft as seen from the ground
144 17 89 66 38 135 242 180

E. 4281-meter peak in Southern Mexico
11 162 104 6 232 13 93 156 28
112 16 124 71 54 223

F. Scottish soldier, 1520-73, involved in intrigues with Mary Stuart
150 148 8 137 202 92 240 20 117

G. Character in Wagner's "Das Rheingold"
80 94 231 3

H. Regularly overlapping, as scales or tiles
229 207 164 109 205 52 173 220 189
172

I. Setting of an Aristophanes comedy
174 23 125 177 243 58 118 140 233
47 166 107 225 25 208

J. Ratio specifying normal vision (2 words)
183 1 59 46 5 182 248 32 99
29 53 133

K. Wisconsin city at the mouth of the Fox River
194 186 216 115 127 149 39

L. Flying reptile of the Lower Jurassic
235 153 191 212 221 85 9 129 251
75 98

M. Describing arteries and motor nerves
171 132 195 35 204 27 119 21

N. Uncle of Norwegian King Olaf Tryggvason and commander of one of his ships (1000 AD; full name)
196 226 131 126 141 178 200 30 152
249 120 157 33 236

O. A gaseous hydrocarbon
7 87 55 241 81 122 230 155

P. "Novelty and _____" Satire by Lewis Carroll (is it two words?)
90 110 244 40 49 60 72 234 201
100 146

Q. Marine cephalopod *Sepia Officinalis*
44 77 18 209 73 252 103 63 192
197

R. Very light gray or ivory (comp)
245 69 82 78 130 42 26 211

S. Island in Bering Strait (2 words)
105 158 227 215 142 19 253 83 134
111 237 50 185

T. English Baronet, 1814-1900, founder of fertilizer industry
160 219 213 116 88

U. Obstructing (3 words)
10 246 61 2 56 15 168 74

V. Novel by George Orwell, 1949 (3 words)
228 86 190 68 203 114 91 4 165
214 170 12 101 163 222 76 139 179

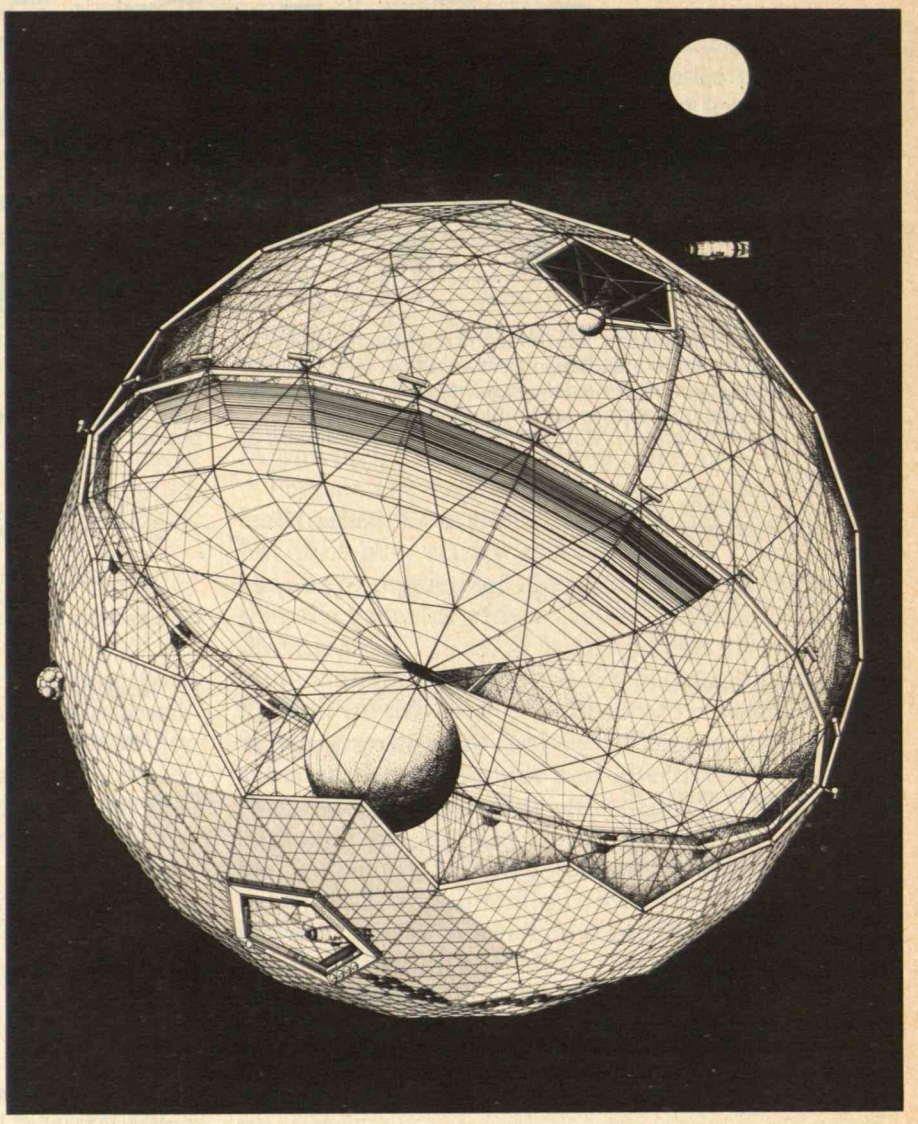
W. Prevaricates a bit (3 words)
36 238 70 151 43 64 147 198 14
41 184 143 96 169 51 145 22

X. Type of coupling for axially misaligned shafts
37 106 175 113 250 188

Y. English satirist, poet, dramatist 1567-1601
34 128 193 154 239

Trend of Affairs

Trends This Month



Above right:
It's called an aerostat, and two scientists from the Franklin Institute's Research Center argued for its deployment in the stratosphere during the 1980s at this year's meeting of the American Association for the Advancement of Science. Perhaps a mile in diameter, the aerostat would collect solar energy to maintain its air temperature at 80° F and power its communication and surveillance equipment. There would be accommodations for a large crew, launching facilities for spacecraft, and plenty of excess solar energy for transmission to earth.

Space

Can Space Profits Save the Space Program?

This year is a critical year — and the 1980s a critical decade — for the future of the U.S. in space. With the flight of the Space Shuttle will come the moment of decision: we must then move decisively to open the new window it will provide to economic and intellectual progress.

That coming necessity should be more obvious than it is, says Gilbert W. Keyes and John T. Bosma of Boeing Aerospace Co. "From a viewpoint of technical and financial risk," they told the American Association for the Advancement of Science last winter, "space ventures rate well below industries such as offshore oil, and, to a certain extent, electronics.

"Space is a surprisingly ordinary economic environment," they said. And they think that fact will become obvious when the shuttle begins regular flights sometime in the 1980s.

But most of the plans for space do not sound ordinary at all. For a macroengineering session at the AAAS (the hotel bulletin curiously listed it as "microengineering"), Stanley G. Rosen of the American Institute of Aeronautics and Astronautics gave a detailed analysis of a space-based nuclear waste disposal program for the twenty-first century — which is by his admission "an enormously complicated systems engineering task." But

only if planning, development, and demonstration are undertaken now will it be "a credible, near-term option to citizens of the twenty-first century," he warned.

Another example, from Ernest C. Okress and R.K. Soberman of the Franklin Institute's Research Center: a solar-powered sphere *one mile* in diameter to be placed in the stratosphere at an altitude of 30 kilometers as a base for surveillance, research communications, and solar energy generation.

Messrs. Keyes and Bosma called attention to the communications satellite industry, a $1-billion success story whose revenues may triple in five years. In addition, they proposed a series of giant antennas in space to serve as future communications centers.

The obstacles to such commercial exploitation of space are financial, organizational, and political — but not technological, they said. What's needed are "sharp increases" in NASA's budgets for 1980-85 together with tax and other financial incentives "to reduce the risks and costs for industries that participate in fledgling space industries." The goal is to let private industry make space systems self-sustaining so that NASA can concentrate on research.

But scientists who want to spend NASA's research money are hardly ready to wait so long. Because of a failure to support space research in the late 1970s, the U.S. faces a four-year period from 1982 through 1985 when no American spacecraft will encounter another planet — "a disastrous four-year gap," said Louis D. Friedman of Jet Propulsion Laboratory. Without new appropriations for the "systematic development" of new scientific programs, Dr. Friedman told the AAAS, "we are in danger of witnessing the [space science] enterprise wither away, to be remembered more as a curio in the history of these times than as a great beginning of a new human endeavor."

Without such support, space may well turn into a military jurisdiction. "We are only beginning to appreciate the full potential of military space systems," Robert A. Davis of Aerospace Corp. told the AAAS. Here, too, the problem is likely to be money. But superimposed on that problem for the military space planner, said Dr. Davis, is the question sharpened by the ever-increasing development time needed for new weapons systems: "How can we be sure that new technology can be introduced at a pace commensurate with its need as well as its availability?" — *J.M.* □

The Rime of the Ancient Sun

Was the youthful sun several billion years ago stronger and hotter or fainter and cooler than it is today? What was it made of? Did it flare? How much energy did it have? Wherefore *Viking* observations of fluvial traces on Mars, attesting to a much warmer climate in the past than in the present on that planet?

We do have some evidence: the sun has left clues to its past nature scattered throughout the galaxy. Meteoroids exposed to the primordial sun have fallen on Earth, and energetic solar particles that long ago streaked through rocks on the moon left behind tracks that can now be discerned and studied. Evidence of changing climates on Earth — for example, in tree rings, ice cores, and sea sediment cores — also offers a natural record of solar behavior.

But interpretation of these clues is hampered by their limited extent. The most complete sequential records are found in ice and sea floor cores accumulated over 50 millennia — not much in terms of solar history. The solar record in meteorites may be older but is subject to great uncertainties — for example, the impossibility of determining where or when a particular meteorite was exposed to the sun. Deducing the time of exposure is also a difficult problem in interpreting lunar samples. But such problems enhance the search, which attracted geologists, physicists, astronomers, planetary scientists, and even historians to an unusually wide-ranging interdisciplinary conference on the ancient sun organized last fall by the Lunar and Planetary Institute.

The arduous and painstaking analysis of the lunar material — particularly the surprising abundance of isotopes — is proving that our sun is much more variable than we had previously believed," said John Eddy of the National Center for Atmospheric Research in Boulder, Col.

No scientist at the conference could deny the dream of studying samples of soil and rock from other planets. But observational evidence may prove to be of value long before chunks of Martian crust join lunar and meteoric samples already on NASA laboratory shelves. For example, hypothesized Owen B. Toon of NASA, present theories of atmospheric evolution suggest that Venus, Mars, and Earth all had massive carbon dioxide atmospheres in the past. Could it be that Venus never lost its original CO_2 atmosphere, instead retaining a thick shroud such as we now find covering that planet's hot surface — far too hot for water to exist? Or did Venus in the distant past have an Earth-like climate — and flowing water? Fluvial features on Venus would be evidence of a faint early sun. Thus, Toon suggested, current progress in mapping the Venusian surface (*see "Venus Unveiled," February, p. 78*) yields important information to both paleontologists and solar physicists.

"I think we're going to find that the sun has changed significantly over time," predicts John Eddy. "Even the tree-ring analyses bear this out — we're living with a variable star." — *Joann T. Dennett* □

A Primordial Yellow Cloud of Life?

The more you look for evidence of life and its precursors in the universe, the more you find and the older it is. The precursors of life may even have been on earth before the formation of its crust.

Until the early 1970s, only about 2,000 meteorites had been identified, among them only 35 of the species called carbonaceous chondrites containing carbon compounds. One of the latter contained amino acids, organic compounds that are a constituent of all proteins and necessary for life — thus suggesting for the first time an extraterrestrial source of such molecules.

But a haunting question remained: Was that meteorite polluted with amino acids from earth while waiting to be found in the Australian outback? If so, we had found remnants of earth's living systems, not precursors of extraterrestrial ones.

Lately a bonanza of these meteorites have been found, and that question is no longer unanswered. Large numbers of meteorites have been recovered from the Arctic and Antarctic, including eight carbonaceous chondrites from the pristine environment of Antarctic ice. The purity of these rare rocks has been assured by "clean room" techniques developed by NASA for studying lunar rock samples, and analysis at the University of Maryland's Laboratory of Chemical Evolution (L.C.E.) confirmed the meteorites' cleanliness *and* the presence of amino acids. Then a surprise: 5 of the 11 different amino acids found in the meteorites were unlike any ever found on earth: a beam of polarized light turns right when passed through the water in which these amino acids are dissolved, while living organisms

on earth contain only "left-handed" amino acids.

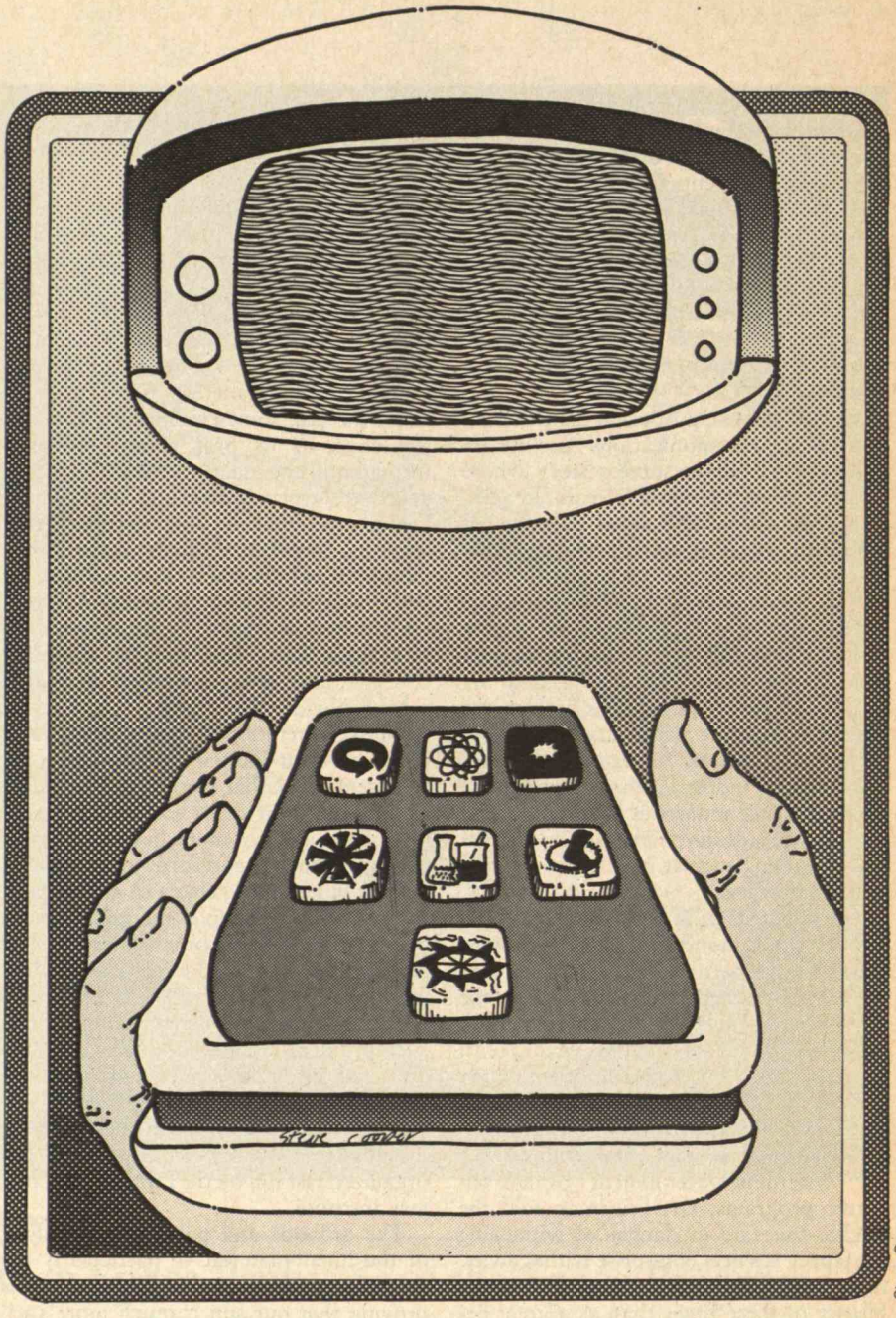
This is "proof that the acids are not the result of a living process, but of a prelife form," Cyril Ponnamperuma, L.C.E.'s director, told the Division of Geochemistry of the American Chemical Society last fall. "The findings give credence to the idea that the chemical evolutionary process postulated for earth has taken place elsewhere," he said.

Further evidence for this hypothesis came from the Astrophysics Laboratory at Leiden University in Holland, where tiny interstellar dust particles afloat in space have been simulated in a vacuum at −263° C — just 10° C above absolute zero. Simulated sunlight shining into this system causes production of "a wide variety of complex organic molecules," many of those identified in the interstellar medium itself, according to J. Mayo Greenberg and his colleagues. But in addition, Dr. Greenberg told the American Chemical Society, he and his associates have seen the build-up of a curious, unidentified "yellow stuff" — a heavy substance (molecular weight 514) containing "carboxylic acid and amino groups of possible biological significance."

The Leiden simulations suggest that perhaps 2 to 20 per cent of all interstellar dust may in fact be this "yellow stuff" — "a total mass as large or larger than that of all the planets in the Milky Way. . . . One cannot resist speculating," Dr. Greenberg said, that "if the solar system at some primordial time passed through a molecular cloud there would have been deposited a layer of dust 0.01 centimeter thick over the entire earth's surface, and the amount of large organic molecules in this mass could conceivably have contributed to the first biological formations."

Attention then turned back to Dr. Ponnamperuma's laboratory, which found organic molecules in rocks collected in Greenland believed to represent the oldest sediments on earth — Clifford Walters of L.C.E. put the age at 3.83 billion years. "Since these are the oldest sediments discovered so far," he told the American Chemical Society, "we must conclude that life is as old as the oldest known rocks."

The next stage, said Dr. Walters, will come if and when some lucky geologist finds a remnant of earth's original crust in which to search for evidence of life. If it can be found, then Dr. Greenberg's hypothesis will have new support. — *J.M.* □



Steve Cooper

Energy

Adding Contrast to a Grey Picture

Repent, ye sinners.
Days of wrath lie ahead.
Destruction is at your doors.
But accept the truth, and ye shall be saved.

Energy prophets, in language more modern, all appear to be saying just that, and they don't even bother to deny the religious overtones. But, as has generally been the case with seers, each one has a slightly different conception of the truth.

Last January in San Francisco, at the annual meeting of the American Association for the Advancement of Science, Lewis J. Perelman (a senior scientist at the Jet Propulsion Laboratory) convened a panel of the "more informed and thoughtful people" concerned with energy to ponder America's sins of the past and to predict "Energy in the 1980s: The Shape of Things to Come." Unanimous in their jeremiads, each speaker outdid his predecessor in envisioning a troubled, energy-competitive world to come:

☐ *Chauncey Starr, vice-chairman of the Electric Power Research Institute*: Our dependence on Middle-Eastern oil will force us to "remain on the brink of catastrophe." And with little or no growth expected in our domestic sources of energy, the future is "none other than dismal."
☐ *John O'Leary, former deputy secretary of the U.S. Department of Energy*: The 1980s will be a period of "unmitigated gloom." Our "national delinquency" during the 1970s caused us to "merely dissipate" our chances, and the use of military force — "a political response from people appalled by the prospect of doing nothing" — is not beyond the pale.
☐ *Richard Ottinger, congressman from New York and chairman of the Subcommittee on Energy Development and Applications*: The administration and the Congress will only "face up" under conditions of a massive crisis.
☐ *Dennis Meadows, professor of engineering and director of the Resource Policy Center at Dartmouth College*: "A very sustained period of low resource availability" lies ahead, from which "no interest group can insulate itself."
☐ *Daniel Yergin, lecturer at the Center for International Affairs at Harvard University*: Our national economy is hemorrhaging; the international energy system is collapsing into anarchy; we make repeated, wishful, but self-destructive excursions into fantasyland; and Chicken Little will be vindicated. "The only cheerful aspect of this panel," he said, "is that we succeeded in getting a larger room."
☐ *Barry Commoner, director of the Center for the Biology of Natural Systems at Washington University*: Our energy system has a tendency to parasitically drain, at an exponentially increasing rate, the economic system it is supposed to support.

Not a pretty picture. But fear not — these prophets all see hope somewhere in the haze. And they all agree that conservation and renewable sources will play major roles in the future. Trouble is, each one hears a different drummer and sees a somewhat dissimilar path.

Congressman Ottinger predicts breakthroughs in photovoltaics and in the (generally overlooked) production of hydrogen by solar means. Mr. Yergin agrees that solar could be big, but its future is uncertain and it shouldn't be oversold. Professor Commoner foresees the large-scale distillation of ethanol from sugar beets (under a rapid transition from our present soybean-based agricultural system). This ethanol, he says, would be a solar solution that could keep us adequately stocked with unleaded gasoline and other fuels while maintaining our present levels of food (i.e., livestock) production.

Skepticism abounded over the administration's proposed program for producing synthetic fuels. Mr. Ottinger called this complex of costly and highly centralized technologies "a dubious phenomenon no matter how much you waste on it." Mr. Yergin said it would divert funds from more effective programs such as energy conservation and renewable energy. Mr. Starr conceded that the required lead time is long — ten years to demonstrate and another ten to build "serious numbers of plants" — but insisted that no path be prematurely rejected. "We are rich enough to afford demonstration projects," he said, even if synfuel technologies never are commercialized. How can we make optimal decisions, he asks, if we limit our options?

John O'Leary supported Mr. Starr's have-it-all-ways approach. "Chauncey and I are on the 'right,' saying let's go with the things we know, such as nuclear and coal. Barry and Dan, in my view, are on the 'left,' saying let's take a chance with things we don't know, such as conservation and solar. Our disagreement, of course, is temporal, but for the nonce, let's not jeopardize our standard of living."

"You miss my point," replied Commoner. "Solar is the *only* way to maintain our standard of living." And Meadows questioned whether, in fact, nuclear power is truly "something we know."

If there was any consensus among the "more informed and thoughtful people," it was that traumatic energy disruptions can be expected in the 1980s and that conservation will consequently gain greater importance. That we must eventually go to renewable sources is to belabor the obvious; but which ones to emphasize, how to develop them, at what cost, and with what amount of pain, no one could say.

Barry Commoner maintained that if we begin now, "we will be essentially wholly on solar within 40 to 50 years." (This reporter thought at first that Dr. Commoner had said "essentially holy.")

And though he tried hard to avoid it, questioners finally nudged Commoner into making one of the Jeremiah-like utterances that have long endeared him to the press: "If we don't begin the transition to renewable energy in the next few years, there will be worldwide catastrophe by 1990." — *S.J.M.* ☐

Microwaves: How Good and How Bad?

Evidence of the remarkable effects on living systems of low-level microwave radiation is converging, and with it come both optimistic forecasts and growing alarm.

Microwaves falling on living tissue do not ionize the atoms within the tissue; they are appropriately called nonionizing radiation, in contrast with ionizing radiation such as x-rays and gamma rays. Microwaves used to be regarded principally as sources of heat. On this basis, it was clear that safety should dictate exposure limits, but the safe limit of human exposure formulated was subjective and very high: no one should experience enough microwave energy to cause severe internal heating.

This standard is now clearly obsolete, and new standards are being proposed by the National Institute of Occupational Safety and Health and the American National Standards Institute. The first changes in the standard became necessary when it was found that living tissue has naturally resonant frequencies; microwaves at these frequencies do more damage than those at nonresonant frequencies.

Now a whole new class of effects from nonionizing radiations of far less intensity — down to a few microwatts per square centimeter — is causing interest and concern:
☐ Birds' navigation is apparently affected by low-level radio waves; the detection system by which sharks seek out their game seems also to be be affected.
☐ Weak pulsating current can influence cell growth — the rate of regeneration of a salamander's amputated limb and the rate of human bone fracture repair and the extent of bone formation and healing. Capitalizing on the latter, some 750 cases of human bone fractures that had otherwise refused to knit have been treated with microwave radiation with a success rate of 75 per cent, according to Arthur H. Pilla of Columbia University.
☐ Microwaves alter brain wave patterns in cats, and human exposure to low levels of radio-frequency energy seems to be associated with generalized lassitude and changes in the immune system. Dr. W. Ross Adey, chief of research at the Veterans Administration Medical Center in Loma Linda, Calif., thinks these effects originate in the very thin membranes across which the human brain's electrical activity occurs. Though the voltages involved are very small in absolute terms,

the gradients are very high, Dr. Adey told the American Association for the Advancement of Science early this year. He hypothesizes that resonance effects may occur involving the calcium ions with which the brain's normal functions are carried out, and he proposed that these results may point the way to using microwaves to alter brain chemistry without drugs or surgery.

Summarizing these developments, Dr. Pilla told the AAAS that "there is strong circumstantial evidence that electrochemical information transfer can beneficially modulate cell function. . . . If this becomes reality, it is not difficult to imagine that selective modulation of cell function in a variety of growth, repair, and pathological processes could be achieved using . . . pulsating low-level current."

"We are on the threshold of communicating directly with the cell," Dr. Don R. Justeson of the Kansas City Veterans' Administration Medical Center told Charles Petit of the *San Francisco Chronicle*.

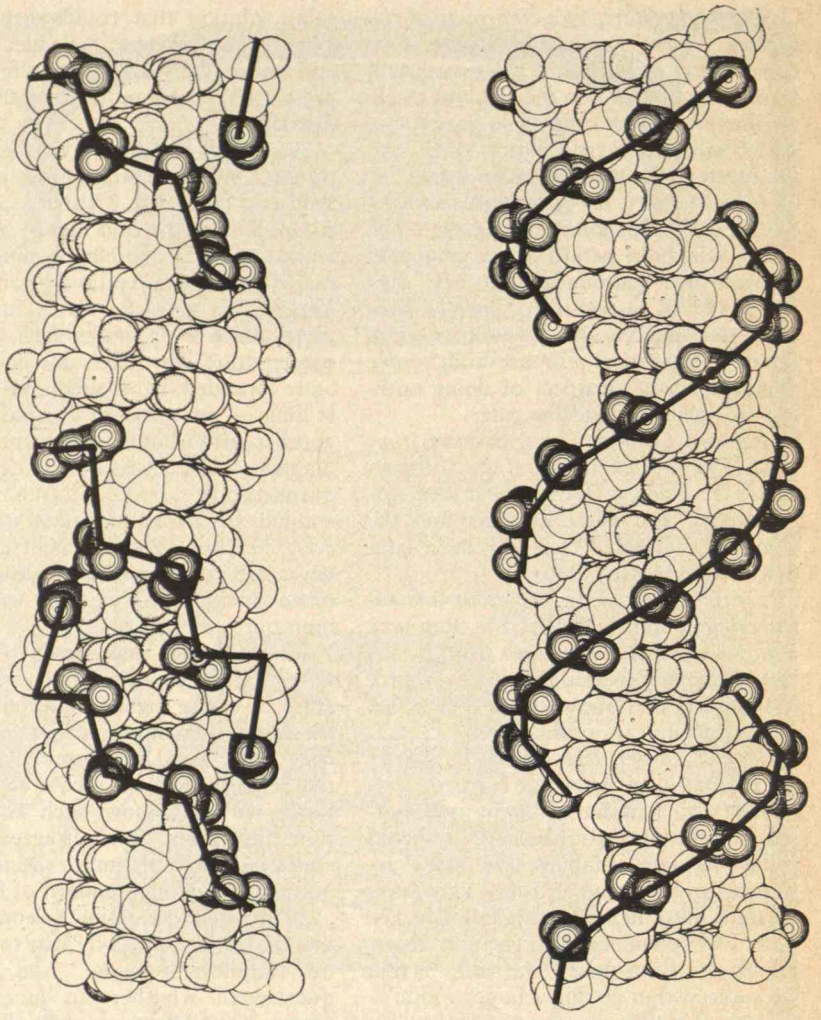
But this growing knowledge about the interaction of microwaves with living things stimulated Andrew A. Malino and Dr. Robert O. Becker of the Veterans Administration Medical Center in Syracuse to express concern that many of their colleagues share. Dr. Becker, a pioneer in using microwave radiation to stimulate bone growth, and Dr. Malino fear that existing standards permit "the exposure of substantial numbers of the U.S. population in an uncontrolled, random, and essentially involuntary manner."

The present Soviet standard for general exposure to broadcast-frequency electric waves is 1 microwatt per cubic centimeter; the U.S. standard, admittedly obsolete, is 10,000 microwatts per cubic centimeter — "a serious public health and ethical problem," according to Drs. Malino and Becker.— *J.M.* □

Biology

An Important New Twist to DNA

A new configuration of DNA — the genetic material that dictates the state and development of all living things — totally different from the one originally outlined by James Watson and Francis Crick a quarter of a century ago has been discovered by an M.I.T. scientific team led by Alexander Rich, Sedgwick Professor of Biophysics.



Right-handed *(right)* and left-handed *(left)* DNA molecule models. On the left-handed form regions called bases with which environmental carcinogens generally combine are exposed and therefore more susceptible to "attack" than are identical bases on right-handed forms. *(Computer graphic: A. Rich)*

He thinks the discovery may have important biochemical implications in such areas as cancer research and basic genetics.

Traditionally, DNA has been described as a right-handed double helix, a twisted ladder of chemical "blocks," the order of which determines an organism's inherited characteristics. The helix Professor Rich now describes (*see* Nature, *December 13, 1979*) has a *left-handed* twist, a shape that lends it a variety of characteristics that are totally distinctive from those of the right-handed form. The study suggests that while most DNA in living cells is right-handed, certain sections of the DNA molecule with a special nucleotide sequence may be folded into a left-handed geometry that distinguishes it from the traditional model.

Professor Rich's new work is based on crystals of DNA segments rather than fibers, or threads. Traditional methods of looking at the molecule consist of exposing these long threads of DNA to x-rays and then examining the scattering of the x-rays to deduce details about its structure.

The technique applied to DNA threads yields imprecise results — specific atoms cannot be distinguished because of disorder in the threads. In the crystalline form, however, there is very little disorder, making it possible to distinguish individual atoms. It was the characteristically higher resolution of crystal diffraction that allowed Professor Rich and his group to define the left-handed geometry of the DNA structure.

This difference in geometry, Professor Rich explains, may cause left-handed DNA to react differently with outside substances. For example, cancer-causing agents are known to react with areas of the DNA molecule known as "bases." In its left-handed form, the specific regions on

bases with which carcinogens generally combine are exposed. This makes them much more susceptible to attack than the right-handed variety. So it is possible to hypothesize a connection between cancer and left-handed DNA.

Professor Rich suggests nature may use this special configuration to regulate the expression of genetic information from different parts of the DNA molecule. The fact that DNA can fold into another form suggests that nature may use alternative foldings to carry out special activities, some of which may be of considerable biological significance.

He cautions, however, that these and other implications of his discovery remain to be substantiated. So far, all he and his team know for sure is that they have found a form of DNA that differs significantly from the model first proposed.— *Ellen Ruppel Shell* □

Environment

Thinking Big About Water

□ "The most significant, profitable, and enduring public investments" in North America during the last 500 years have been those related to the engineering and managing of the continent's major river systems.

□ While full exploitation of much of the western part of the U.S. and Canada is limited by water shortages, over 350,000 cubic feet per second of fresh water drain into James Bay from a 250,000-square-mile area of Quebec and Ontario.

Thomas W. Kierans, director of the Alexander Graham Bell Institute at the College of Cape Breton, Sydney, Nova Scotia, has a vision that combines those two ideas — the Great Replenishment and Northern Development (GRAND) Canal Concept. The GRAND Canal would collect some (or perhaps all) of the fresh water just as it flows into James Bay, return it (by pumping and by harnessing its own power) to the U.S.-Canadian Great Lakes, and move it from there as needed to control flows in the Great Lakes and to irrigate the fertile lands to the south and west.

Such a copious supply of fresh water — with the flow rate of four Niagara Falls — would be the key to a water management system for much of the rest of the North American continent, says Dr. Kierans. In the Great Lakes and the St. Lawrence River, water levels could be controlled easily and water quality improved. In the eastern United States, river flows could be controlled to eliminate floods and low water. Water from the Great Lakes could be distributed to the Canadian midwest, the U.S. great plains, and even the desert Southwest to provide irrigation and improve flood control. In the Canadian north, renewable water resources could provide a basis for industrial development.

To skeptics who think this macroengineering project sounds a little overpowering, Dr. Kierans cites two precedents:

□ A significant flow of waste water is diverted from Lake Michigan into the Mississippi River to protect the lake from Chicago's pollution. As a result, Lake Michigan is by far the cleanest of the southern Great Lakes.

□ Water from the Sacramento River is recycled by California's Central Valley Project just before it is lost to the sea near San Francisco — it is turned south to irrigate deserts as far away as Los Angeles. The cost, Dr. Kierans says, may have been $2 billion in 1960 dollars. But the irrigation water helps produce food worth more than $10 billion annually.

"Apply the cost-benefit ratio of the Central Valley Project to the ten-times-greater area of the U.S. and Canada with chronic, multi-use water problems or low land values due to water deficiency," says Dr. Kierans, "and you see the merit of encouraging the GRAND Canal." — *J.M.* □

CO_2, Salt, and the World Food Supply

Cries of alarm about future climate change (higher average temperatures due to increased carbon dioxide from fossil fuel) are familiar enough. But no outcries have come yet from the world's food producers. Indeed, though the link and its dimensions are not wholly clear, the postulated climate change may have positive effects on many familiar agricultural systems and help make possible some innovative new ones.

Sylvan H. Wittwer, director of the Agricultural Experiment Station at Michigan State University, radiated optimism in a paper prepared for the annual meeting of the American Association for the Advancement of Science in San Francisco early this year. Without exception, said Professor Wittwer, current research shows that plants grow faster in atmospheres enriched in carbon dioxide (CO_2), and even very small increases in average temperatures will also spur productivity. He proposes that the increase in atmospheric CO_2 from 290 to 335 parts per million between 1860 and 1979 "may already be making a significant contribution to the productivity of agriculture and other renewable resources."

To capitalize on this effect in the future, Professor Wittwer advocates a new program of research to study effects of CO_2 and other conditions likely in tomorrow's world.

Just in case things don't work out as anticipated on land, look for increased emphasis on aquaculture. Professor Carl N. Hodges of the University of Arizona's Environmental Research Laboratory thinks aquaculture in its present forms has been "oversold," but he is still optimistic. He told the AAAS that in the long term, systems in which seawater is used to grow marine algae, seaweed, and even aquatic animals may become practical, citing a successful shrimp culture system as a promising example.

Dr. Hodges' vision of the future hinges on exploiting halophytes — salt-tolerant plants such as those that now flourish in coastal marshes and estuaries. He and some colleagues have already established desert farms in Mexico that are irrigated with salt water. Fast-growing plants containing as much protein as wheat and soybeans are "thriving" in the hot, strong desert sun, he said, and he thinks that similar plants may also thrive on croplands unsuitable for conventional agriculture because of salt concentrations due to accumulated evaporates from irrigation water. Dr. Hodges' analyses indicate that his halophytes will be "directly digestible" by ruminant animals, and he plans some "large-scale" tests with cattle before the end of the year.— *J.M.* □

Will CO_2 Make the Strong Stronger?

If world agriculture has to adapt to a long-term climate change involving increasing atmospheric carbon dioxide and higher average temperatures during the next half-century (*see above*), the effect will probably be to make the strong stronger and the weak weaker.

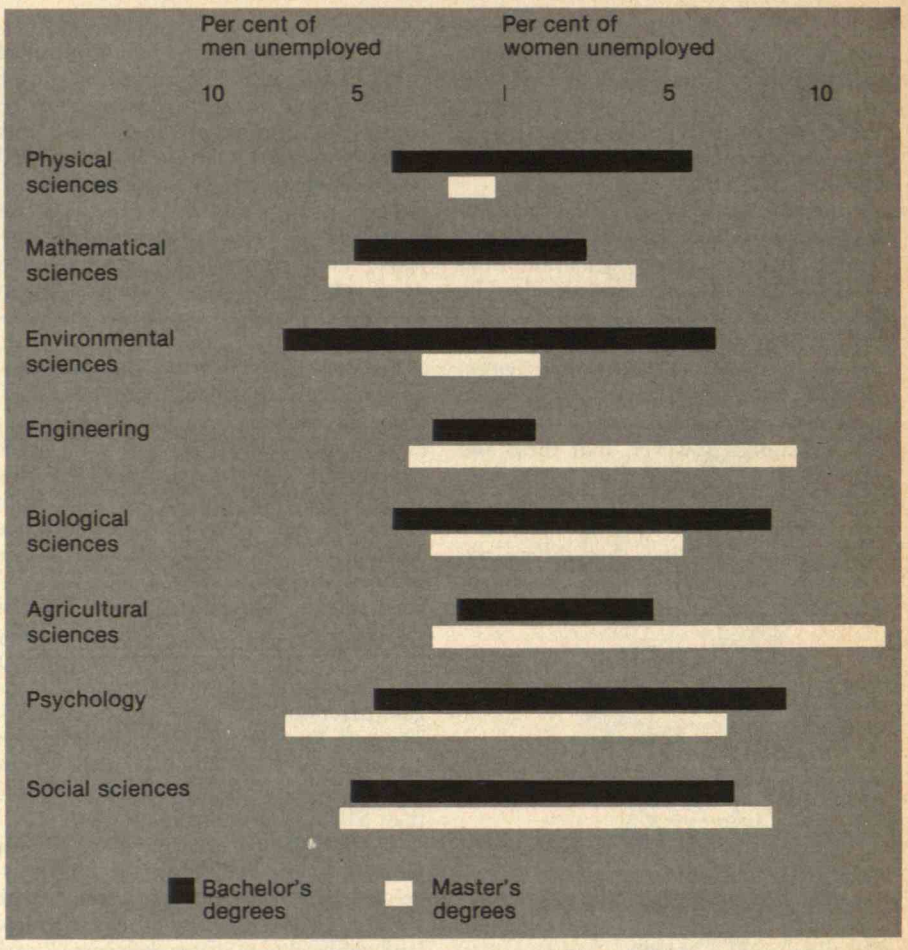
History helps nurture such a conclusion. The International Federation of Institutes for Advanced Study concludes

that only in the weakest economies are large-scale economic dislocations likely from such events as the early-1970s droughts in the Sahel (Africa), India, and the Soviet Union.

A prolonged drought in the U.S. created the "dust bowl" of the 1930s, but the nation as a whole was not brought even close to starvation; it drew upon stockpiles, imported food, and substituted more plentiful crops for the grains lost on the plains. But when drought hit North Africa in the early 1970s, the nations of the Sahel had no such alternatives; there was widespread suffering and death.

"What happens after drought has struck is much more determined by the structure of the whole ecosystem, including its social components, than by the drought itself," Stanley Ruttenberg of the National Center for Atmospheric Research told the American Association for the Advancement of Science early this year.

The CO_2 threat of the future may well present challenges that economically strong nations can meet with new institutional and technical defenses (as the U.S. did following the 1930s by changing the character of farming on the plains). Indeed, such changes may strengthen the agricultural system overall. But "subsistence economies," lacking resources for defenses and change, are likely to remain "desperately vulnerable" to whatever nature — or humankind — next throws their way, said F. Kenneth Hare, provost of Trinity College of the University of Toronto.— *J.M.* □



Unemployment as a measure of discrimination. Two years after they graduated, more men than women in the class of 1976 had jobs in science and engineering, and a far larger proportion of women than men were in the ranks of the unemployed. (*Data: National Science Foundation*)

Last Line

Women Still on the Short End of Science

Though the proportion of women to men earning degrees in science rose at a "remarkable" rate during the 1970s, discrimination is by no means a thing of the past: women still make up "a much smaller proportion of the scientific and engineering labor force than their share of earned degrees would indicate," Betty M. Vetter, director of the Scientific Manpower Commission, told the American Association for the Advancement of Science this winter.

A survey by Ms. Vetter's commission reveals that women with degrees in science and engineering are much more likely to be working or seeking work than women with degrees in other fields; the figure is 80 per cent (85 to 90 per cent for those with graduate degrees), compared with an average of about 70 per cent.

But that finding didn't answer Ms. Vetter's central question: What happens to the women who graduate in science and engineering but don't show up in the labor force?

□ Some of them — on average, more women than men — are employed outside science and engineering. Some — again, more women than men — said this was because they couldn't get jobs in their fields.

□ Many women with children under six years of age elect not to work. But that's not the whole story, because more mothers are working in fields where the demand — and the salaries — are high than in fields where demand — and salaries — are low.

□ Women who have dropped out of the labor force to raise their families have trouble returning to the office or laboratory. Programs to help them return to professional life are only marginally successful.

Further evidence of continuing discrimination against women in science and engineering: except in the engineering disciplines, Ms. Vetter finds, women are paid less than men.

In all, she said, there are 730,000 women with at least one science or engineering degree earned within the last 25 years who are not now working. Many don't want to, said Ms. Vetter, but many others simply "do not know how to begin." — *J.M.* □

Solution to March/April Crostic

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George Sarton, *The Life of Science*

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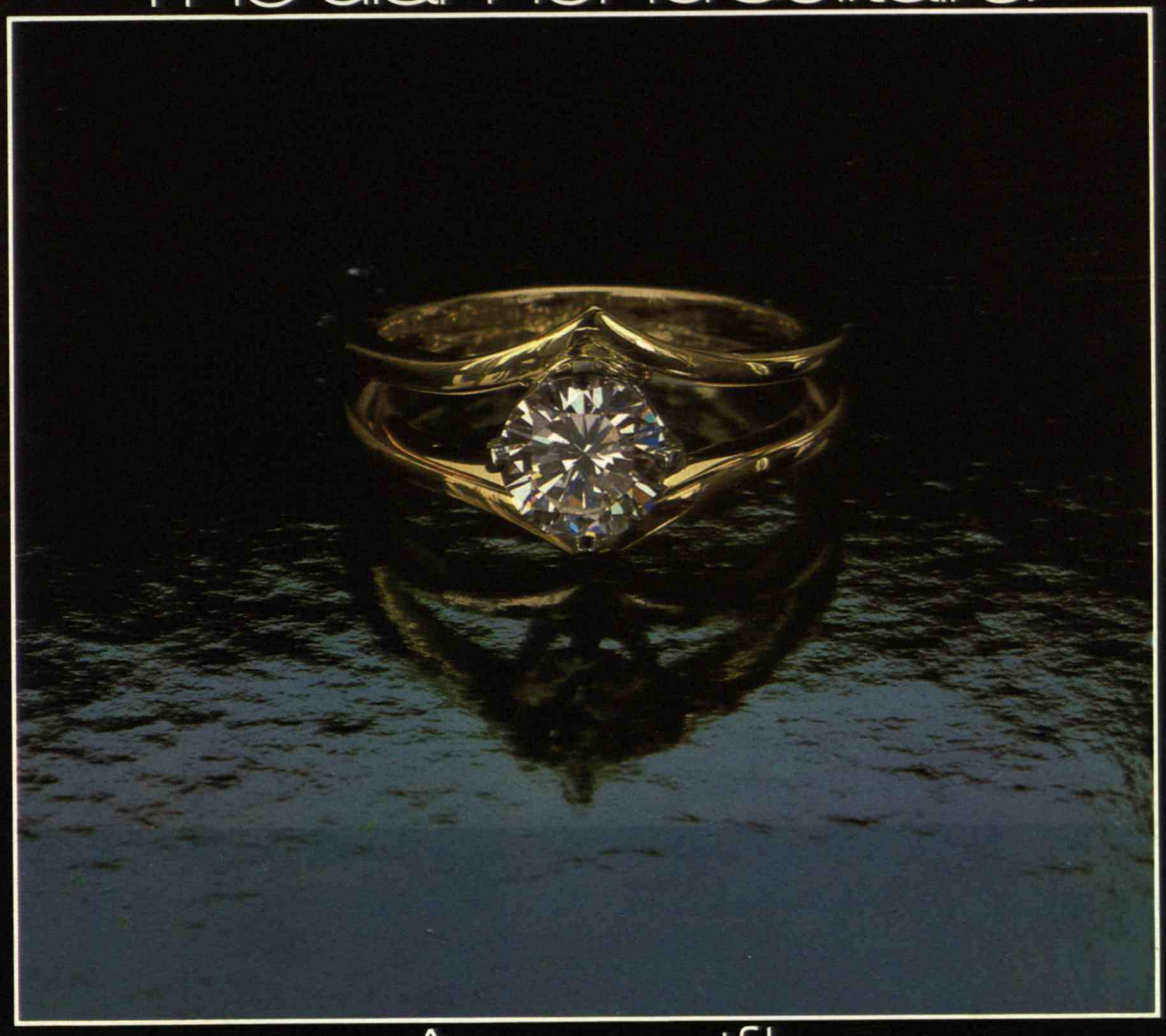

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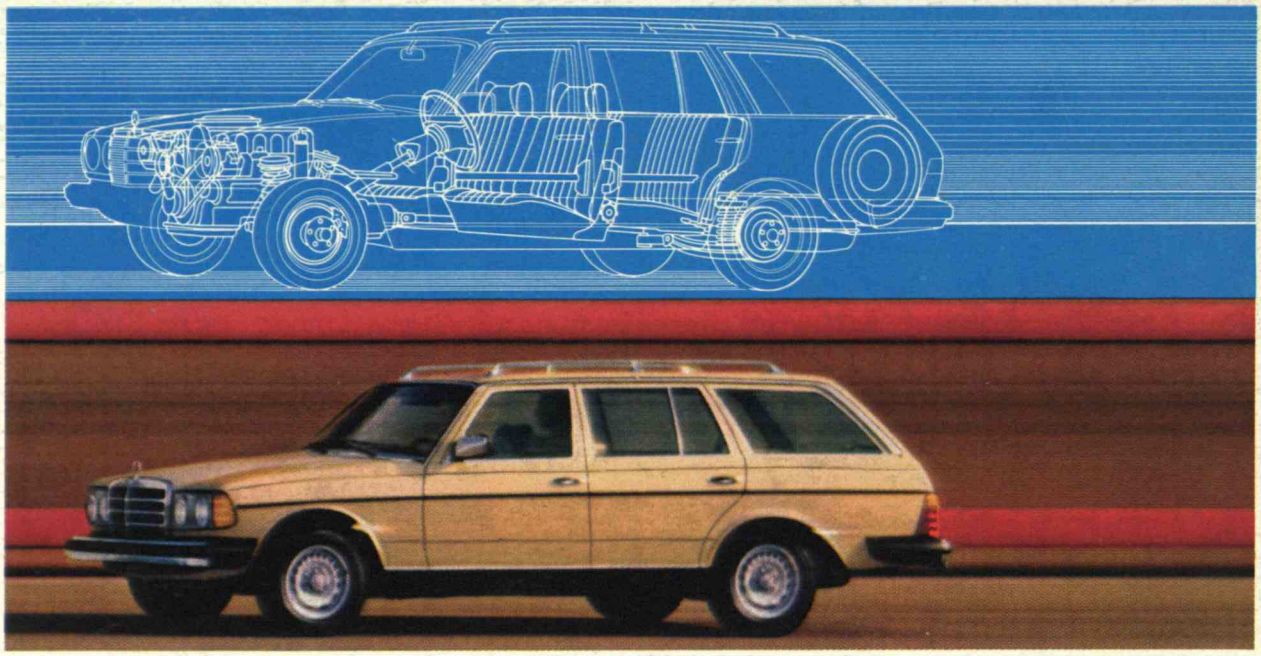

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